ANSI C63.4-1992
(Revision of ANSI C63.4-1991)

American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

Accredited Standards Committee On Electromagnetic Compatibility, C63

accredited by the

American National Standards Institute

secretariat

Institute of Electrical and Electronics Engineers, Inc.

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Abstract: Uniform methods of measurement of radio noise emitted from low-voltage electrical and electronic equipment, including digital and other information technology equipment, in the frequency range of 9 kHz to 40 GHz are set forth. Both unintentional and certain intentional radiators are included. Methods for the measurement of radiated and powerline conducted radio noise are covered and may be applied to any such equipment unless otherwise specified by individual equipment requirements.

Keywords: conducting ground plane, conducted emission testing, digital equipment, electric field measurement, information technology equipment, intentional radiators, line impedance stabilization network, low-voltage electrical equipment, low-voltage electronic equipment, magnetic field measurement, normalized site attenuation, periodic intentional radiators, powerline conducted radio noise, radiated emission testing, radio-noise emissions, radio-noise power, site attenuation, unintentional radiators.

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Foreword

(This foreword is not a part of C63.4-1992, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.)

Almost from the beginning of radio broadcasting, the electric utility companies were faced with the problem of radio noise. In 1924 the National Electric Light Association appointed a committee to study the subject. The manufacturers of electric power equipment had encountered similar problems, and in 1930, a subcommittee of the NEMA Codes and Standards Committee was set up. The following year the EEI-NEMA-RMA Joint Coordination Committee on Radio Reception was organized.

The Joint Coordination Committee issued a number of reports, among which was Methods of Measuring Radio Noise, 1940. This report included specifications for a radio-noise and field-strength meter for the frequency band 0.15 MHz to 18 MHz. The report recommended procedures for measuring radio-noise voltage (conducted noise) from low- and high-voltage apparatus, making noise field-strength measurements near overhead powerlines, determining broadcast field strengths, and collecting data upon which to base tolerable limits for radio noise.

During World War II, the needs of the armed services for instruments and methods for radio-noise measurement, particularly at frequencies higher than the broadcast band, became pressing and, in 1944, work on developing suitable specifications was begun by a special subcommittee of ASA Sectional Committee C63, Radio-Electrical Coordination. This special subcommittee developed a wartime specification that became Army-Navy Specification JAN-I-225 issued in 1945 and later approved as C63.1-1946, American War Standard-Method of Measuring Radio Interference of Electrical Components and Completed Assemblies of Electrical Equipment for the Armed Forces from 150 Khz to 20 Mhz.

In 1951, ASA Sectional Committee C63, through its Subcommittee No. 1 on Techniques and Developments, started work on improving and extending measurement methods, taking into account methods mentioned in the 1940 report and those in current military specifications. In the course of this work, Subcommittee No. 1 developed the standard C63.4-1963, Radio-Noise Voltage and Radio-Noise Field Strength, 0.015 to 25 Mhz, Low-Voltage Electric Equipment and Nonelectric Equipment. Work continued within the subcommittee on developing methods of measurement above 25 Mhz and the subsequent inclusion of these measurement methods in future revisions of C63.4-1963.

The standard C63.4-1963 was reaffirmed in 1969, and work within the subcommittee was accelerated to produce a draft standard that would make use of the experience gained by several years' use of the standard, to extend its coverage to embrace a broader frequency range and to incorporate newer measurement techniques that had been developed within the USA and by the International Special Committee on Radio Interference (CISPR) as set forth in CISPR Publications 14 and 16. The revised standard was published in 1981.

Although many improvements had been made in standard C63.4 in the several revisions, the reproducibility of measurements of radiated interference from one test site to another had not been completely satisfactory. In 1982 a concerted effort was organized in Subcommittee No. 1 of the American National Standards Committee C63 to determine how the technique could be improved. Evidence showed that the variability was due, in part, to inadequate (1) control of site ground plane conductivity, flatness, site enclosures, effects of surrounding objects, and certain other site construction features, (2) accounting for antenna factors, associated cabling, and balun and device under test characteristics and (3) consideration of mutual coupling effects between the device under test and the receiving antenna and their images in the ground plane. Accordingly, standard C63.4 was further revised in 1988 and standards C63.5, C63.6, and C63.7 were prepared to provide additional information.

In late 1988 and in 1989 the importance of including additional details on test procedures to provide proper evaluation of complex systems, such as information technology equipment and systems, was recognized. Measurements on such systems can be quite sensitive to the exact configuration of equipment units and interconnecting cables. The 1991 edition was the result of a major effort on the part of the members of the Committee and various other participating individuals.

Work on a further revision began during 1991 to provide for the testing of intentional as well as unintentional radiators. Thus these are covered in the present document. The following members of the C63 Committee served as task group leaders on this revision:

Edwin L. Bronaugh	Don Heirman	Ray Magnuson
Jon Curtis	H. R. Hofmann	Ralph Showers
Rich Fabina		Art Wall

At the time that the Accredited Standards Committee on Electromagnetic Compatibility, C63, approved this standard, it had the following membership:

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CLAUSE PAGE

American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

1. Introduction

1.1 Scope

This standard sets forth uniform methods of measurement of radio-frequency (RF) signals and noise emitted from both unintentional and intentional emitters of RF energy in the frequency range 9 kHz to 40 GHz. Methods for the measurement of radiated and ac powerline conducted radio noise are covered and may be applied to any such equipment unless otherwise specified by individual equipment requirements.

These methods cover measurement of certain devices that deliberately radiate energy, such as intentional emitters, but does not cover licensed transmitters. This standard is not intended for certification/approval of avionic equipment or for industrial, scientific, and medical (ISM) equipment.

These methods apply to the measurement of individual units or systems comprised of multiple units. Additional methods may be added to this standard to fulfill future requirements as needed. The methods used for validation of test sites, such as open area sites and absorber-lined rooms for frequencies in the range of 30 to 1000 MHz, are contained in this standard. Further work on absorber-lined room validation is under consideration. An effort has been made, wherever possible, to harmonize the measurement procedures contained herein with those in effect internationally.

1.2 Applications

The procedures contained herein are to be used for determining compliance of a wide variety of equipment with applicable standards for that equipment. They may be used, for example, to test small hand-held electronic devices such as portable computers or garage door openers, as well as to test larger equipment units such as electronically controlled gas station pumps or ensembles of computers such as might be found serving a banking or insurance center. Other procedures may be used in certain instances provided the methods used yield results that are expected to be the same as the results that would be obtained using the procedures contained in this standard. In the event of any dispute, the results of tests performed in accordance with the procedures described herein will prevail over the results of tests performed using other methods. Any persons contemplating using other procedures may want to determine, before performing the alternate procedures, that those alternate procedures are acceptable to the appropriate agency or procuring organization requiring the testing.

This standard, having rather broad applicability, contains clauses that may be selectively incorporated in a specific product requirement. Any procurement or regulatory requirement should contain the following information:

1) Limits and frequency ranges for both ac powerline conducted and radiated measurements
2) For radiated measurements, limits and test distances
3) A specific affirmative statement if any or all of the following are required:
   a) Radiated magnetic field strength measurements below 30 MHz (see 8.2.1)
   b) Radiated electric field strength measurements below 30 MHz (see 8.2.2)
   c) Use of the absorbing clamp as a substitute for measuring radiated field strength (see Section 9)
   d) Use of a 5 μH λινε-impedance stabilization network (LISN) (see 4.1.2)
   e) Current rather than voltage measurements (see 4.1.4)
   f) Relaxation of the limits for clicks (transients) (see Section 14)
   g) Artificial hand (see 5.7)
4) Any requirements concerning the test facilities or test procedures used if the facilities or procedures do not fully comply with the requirements contained herein

Where dimension/distance tolerances are not specified, nominal tolerances are assumed, based upon good engineering practice.

Wherever the word *shall* is used in this document, it is considered to be mandatory. The word *should* is advisory only.

1.3 How to Use this Document

This document addresses a broad range of criteria applicable to the testing of a variety of devices and equipment. All sections may not be applicable to all items subject to testing. The nature of this document is to specify general conditions that are applicable to all equipment covered under its scope and to supplement these general conditions with specific requirements for individual equipment types where appropriate. The specific requirements take precedence over those outlined in the general sections. See Appendix J for guidance in applying this document to specific types of equipment by category.

2. References

The following references shall form a part of this standard to the extent that they are referenced herein. When American National Standards and IEEE Standards are superseded by a revision, the version specified in this document shall apply.

[1] ANSI C63.2-1987, American National Standard for Instrumentation—Electromagnetic Noise and Field Strength, 10 kHz to 40 GHz—Specifications.[1]

[2] ANSI C63.5-1988, American National Standard for Calibration of Antennas Used for Radiated Emissions Measurements.

[3] ANSI C63.6-1988, American National Standard Guide for the Computation of Errors in Open-Area Test Site Measurements.

[4] ANSI C63.7-1988, American National Standard Guide for Construction of Open Area Test Sites for Performing Radiated Emission Measurements.

[1]C63 publications are available from the Institute of Electrical and Electronics Engineers, Service Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331 USA or from the Sales Department, American National Standards Institute, 11 West 42nd St., New York, NY 10036 USA.

[5] CISPR Publication 14 (1985), Limits and Methods of Measurement of Radio Interference Characteristics of Household Electrical Appliances, Portable Tools and Similar Electrical Apparatus.[2]

[6] CISPR Publication 16 (1987), CISPR Specifications for Radio Interference Measuring Apparatus and Measurement Methods, 2nd ed.

[7] CISPR Publication 22 (1985), Limits and Methods of Measurement of Radio Interference Characteristics of Information Technology Equipment. (See also [B3].)[3]

[8] EIA 378 (Aug., 1970), Measurement of Spurious Radiation from FM and TV Broadcast Receivers in the Frequency Range of 100 to 1000 MHz—Using the EIA Laurel Broadband Antenna.[4]

[9] FCC 47 CFR Part 15, Radio Frequency Devices (1990).[5]

[10] IEEE Std 100-1988, IEEE Standard Dictionary of Electrical and Electronics Terms—4th ed. (ANSI)[6]

[11] IEEE Std 139-1988, IEEE Recommended Practice for the Measurement of Radio Frequency Emission from Industrial, Scientific, and Medical (ISM) Equipment Installed on User's Premises (ANSI).

[12] IEEE Std 149-1979 (Reaff 1990), Test Procedures for Antennas (ANSI).

[13] IEEE Std 187-1990, IEEE Standard on Radio Receivers: Open Field Method of Measurement of Spurious Radiation from FM and Television Broadcast Receivers (ANSI).

[14] IEEE Std 213-1987 IEEE Standard Procedure for Measuring Conducted Emissions in the Range of 300 kHz to 25 MHz from Television and FM Broadcast Receivers to Power Lines (ANSI).

[15] IEEE Std 291-1991, IEEE Standard Methods for Measuring Electromagnetic Field Strength of Sinusoidal Continuous Waves, 30 Hz to 30 GHz.

[16] IEEE Std 474-1973 (Reaff 1982), IEEE Standard Specifications and Test Methods for Fixed and Variable Attenuators, DC to 40 GHz (ANSI).

[17] MIL-STD-45662, Military Standard Calibration Systems Requirements.[7]

[18] Hewlett Packard Co. Application Note 150-2, “Spectrum Analysis—Pulsed RF.”[8]

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[2]CISPR publications are available from the International Electrotechnical Commission, 3 rue de Varembé, Case Postale 131, CH-1211, Geneve 20, Switzerland/Suisse. In the US, CISPR publications are available from the Sales Department, American National Standards Institute.

[3]Bracketed numbers preceded by B correspond to those of the Bibliography in Section 15.

[4]EIA publications are available from Global Engineering, 1990 M Street NW, Washington, DC 20036 USA.

[5]For information on how to purchase FCC publications, contact the Superintendent of Documents, US Government Printing Office, Washington, DC 20402 USA.

[6]IEEE publications are available from the Institute of Electrical and Electronics Engineers, Service Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331 USA.

[7]MIL publications are available from the Director, US Navy Publications and Printing Service, Eastern Division, 700 Robbins Avenue, Philadelphia, PA 19111 USA.

[8]This publication can be ordered from Regional Sales Assistance, Hewlett-Packard Co., 1212 Valley House Drive, Rohnert Park, CA 94928-4999 USA.

3. Definitions And Acronyms

3.1 Definitions

The definitions in IEEE Std 100-1988 [10][9], unless otherwise noted below, apply throughout this document. Definitions in particular product standards or in applicable regulations take precedence.

accessory: Any device associated with another device that adds to the convenience or effectiveness of the latter.

ambient level: The values of radiated and conducted signal and noise existing at a specific test location and time when the test sample is not activated.

antenna factor: A factor that, when properly applied to the meter reading of the measuring instrument, yields the electric field strength in volts/meter or the magnetic field strength in amperes per meter.

NOTES:

1 — This factor includes the effects of antenna effective length and mismatch and may include transmission line losses.

2 — The factor for electric field strength is not necessarily the same as the factor for the magnetic field strength.

3 — The antenna factor as determined in ANSI C63.5-1988 [2] is very nearly equal to the free-space antenna factor.

antenna transfer switch: A device used to alternate between the reception of over-the-air RF signals via connection to an antenna and the reception of RF signals received by any other method.

broadcast receiver: A device designed to receive transmissions from a licensed station on frequencies that are authorized for commercial or public broadcasting.

click: A disturbance of a duration less than a specified value when measured under specified conditions.

NOTE — For the specified values and conditions, guidance may be found in International Special Committee on Radio Interference (CISPR) Publications 14 (1985) [5], 16 (1987) [6], and 22 (1985) [7].

conducted emissions test site: A site meeting specified requirements suitable for measuring radio interference voltages and currents emitted by an equipment under test (EUT).

conducting ground plane: A conducting fiat surface or plate that is used as a common reference point for circuit returns and electric or signal potentials, and that reflects electromagnetic waves.

digital device: An information technology equipment (ITE), which falls into the class of unintentional radiators, that uses digital techniques and generates and uses timing signals or pulses at a rate in excess of 9000 pulses per second.

(electromagnetic) disturbance: Any electromagnetic phenomenon that may degrade the performance of a device, piece of equipment, or system, or adversely affect living or inert matter.

NOTE — An electromagnetic disturbance may be a noise, an unwanted signal, or a change in the propagation medium itself.

(electromagnetic) emission: The phenomenon by which electromagnetic energy emanates from a source.

equipment under test (EUT): A device or system used for evaluation that is representative of a product to be marketed.

floor-standing equipment: Equipment designed to be used directly in contact with the floor, or supported above the floor on a surface designed to support both the equipment and the operator (e.g., a raised computer floor).

host: A device to which other devices (peripherals) are connected and which generally controls those devices.

[9]The numbers in brackets correspond to those of the references in Section 2; when preceded by B, they correspond to those of the Bibliography in Section 15.

incidental radiator: A device that produces RF energy during the course of its operation, although the device is not intentionally designed to generate or emit RF energy. Examples of incidental radiators are dc motors, mechanical light switches, etc.

information technology equipment (ITE): Unintentional radiator equipment designed for one or more of the following purposes:

(1) Receiving data from an external source (such as a data input line or via a keyboard);
(2) Performing some processing functions of the received data (such as computation, data transformation or recording, filing, sorting, storage, transfer of data);
(3) Providing a data output (either to other equipment or by the reproduction of data or images).

NOTE — This definition includes electrical/electronic units or systems that predominantly generate a multiplicity of periodic binary pulsed electrical/electronic waveforms and e. re designed to perform data processing functions such as word processing, electronic computation, data transformation, recording, filing, sorting, storage, retrieval and transfer, and reproduction of data as images.

intentional radiator: A device that intentionally generates and emits RF energy by radiation or induction.

interface cable: An interconnecting cable or wire used in an ITE system to carry information.

line impedance stabilization network (LISN): A network inserted in the supply mains lead of apparatus to be tested that provides, in a given frequency range, a specified load impedance for the measurement of disturbance voltages and that may isolate the apparatus from the supply mains in that frequency range. *Syn:* artificial mains network.

NOTE — An LISN unit may contain one or more individual LISN circuits.

low-voltage electrical and electronic equipment: Electrical and electronic equipment with operating input voltages of up to 600 Vdc or rms ac.

normalized site attenuation (NSA): Site attenuation divided by the antenna factors of the radiating and receiving antennas (all in linear units).

peripheral device: A digital accessory that feeds data into or receives data from another device (host) that, in turn, controls its operation.

personal computer: A system containing a host and a limited number of peripherals designed to be used in the home or in small offices, which enables individuals to perform a variety of computing or word processing functions or both, and which typically is of a size permitting it and its peripherals to be located on a table surface.

NOTE — Other definitions given in product standards or applicable regulations may take precedence.

powerline conducted radio noise: Radio noise produced by equipment operation, which exists on the powerline of the equipment and is measurable under specified conditions.

NOTE — It may enter a receptor, such as ITE, by direct coupling or by subsequent radiation from some circuit element.

radiated emissions test site: A site meeting specified requirements suitable for measuring RF fields radiated by an EUT.

radiated radio noise: Radio-noise energy in the form of an electromagnetic field including both the radiation and induction components of the field.

radio noise: An electromagnetic noise that may be superimposed upon a wanted signal and is within the RF range. For the purposes of this standard, an electromagnetic disturbance of a sinusoidal character is also considered radio noise.

restricted band: A band of frequencies in which intentional radiators are not permitted to operate.

NOTE — For FCC application of this standard, see [9].

site attenuation: The ratio of the power input of a matched, balanced, lossless, tuned dipole radiator to that at the output of a similarly matched, balanced, lossless, tuned dipole receiving antenna for specified polarization, separation, and heights above a fiat reflecting surface. It is a measure of the transmission path loss between two antennas.

NOTE — The above is the classical definition of site attenuation. In this document, it is extended to cover broadband antennas as well as tuned dipole antennas.

system: An arrangement of interconnected devices and their cables designed to perform a particular function or functions.

tabletop device: A device designed to be placed and normally operated on the raised surface of a table, e.g., most personal computers.

TV interface device: An unintentional radiator that produces or translates in frequency a radio carrier modulated by a video signal derived from an external or internal signal source, and which feeds the modulated RF energy by conduction to the antenna terminals or other nonbaseband input connections of a television broadcast receiver.

unintentional radiator: A device that generates RF energy for use within the device, or sends RF signals by conduction to associated equipment via connecting wiring, but which is not intended to emit RF energy by radiation or induction.

3.2 Acronyms

CISPR	International Special Committee on Radio Interference
CSTD	cable system terminal devices
CW	continuous wave
EIA	Electronic Industries Association
EUT	equipment under test
FCC	Federal Communications Commission
ISM	industrial, scientific, and medical
ITE	information technology equipment
LISN	line impedance stabilization network
NIST	National Institute of Standards and Technology
NSA	normalized site attenuation
NTSC	National Television Systems Committee
RC	resistor-capacitor
RF	radio frequency
VCR	video cassette recorder
VITS	vertical interval test signal
VSWR	voltage standing-wave ratio

4. Measurement Instrumentation

4.1 General

Use of proper measurement instrumentation is critical to obtaining accurate, reproducible results. Various measuring accessories that may be needed depend upon the particular measurements to be performed as indicated below.

4.1.1 Measuring Instruments

Measurements of radiated and ac powerline conducted radio noise shall be made with a measuring instrument conforming to ANSI C63.2-1987 [1] or with a spectrum analyzer. Where there is disagreement on the results of a test, data obtained with equipment conforming to ANSI C63.2-1987 shall take precedence.

4.1.1.1 Reference Receiver

The reference receiver for measurements of radiated and ac powerline conducted radio noise is a measuring instrument conforming to ANSI C63.2-1987 [1]. Other instruments may be used for certain restricted and specialized measurements when data so measured is correlated to a meter conforming to ANSI C63.2-1987. Automatic scan receivers may be used, but the maximum scan speed shall be limited by the response time of the measuring system and the repetition rate of the radio noise to be measured so as to ensure that the level of each emission is measured correctly, i.e., in accordance with a measurement with a nonscanning receiver. Bandwidth and scan rates shall be chosen that are appropriate for the frequencies being scanned.

NOTES:

1 — For quasi-peak detectors, the requirements in C63.2-1987 are the same as those in CISPR Publication 16-1987 [6] for “quasi-peak instruments” in Bands A, B, C, and D.

2 — If the output of the quasi-peak or average detector is indicated in decibels (dB) or other logarithmic units, the logarithms shall be taken after the signal is detected and the detector function is fully realized. Otherwise, instruments that use logarithmic detectors or predetection logarithmic circuits or both shall include corrective circuits so that the output indication is the logarithm of the true average or quasi-peak value of the signal and/or noise.

4.1.1.2 Spectrum Analyzer

When a spectrum analyzer is used. it shall be provided with appropriate accessories to provide sufficient sensitivity and overload protection to ensure accurate, repeatable measurements of all emissions over the specified frequency range. The autoscan limitations of 4.1.1.1 also apply to spectrum analyzers.

NOTES:

1 — The accessories needed will depend upon the specific measurement task and may include preamplifiers for improving sensitivity, filters and attenuators for overload protection, and additional quasi-peak detection circuits.

2 — Overload includes harmonic distortion, intermodulation distortion, and gain compression of spectrum analyzer input signals.

3 — If a post-detector filter is used, its bandwidth shall be wide enough so as to not affect peak detector readings.

4.1.2 Line Impedance Stabilization Network (LISN)

An LISN, sometimes also called an artificial mains network, having an impedance characteristic within the limits shown in Fig 1, is required for conducted radio-noise measurements. When the “measuring instrument” ports are terminated in 50 Ω, the characteristic impedance in Fig 1 shall be present at the EUT ports of the LISN. Figures 2 and 3 show two circuits that will provide the specified impedance over the frequency ranges of 0.15 to 30 MHz and 0.01 to 0.15 (30) MHz, respectively.

Where specific equipment requirements specify another LISN, for example IEEE Std 213-1987 [14], that LISN shall be used.

NOTE — The extension of the impedance characteristic shown in Fig 1 down to 9 kHz is under consideration.

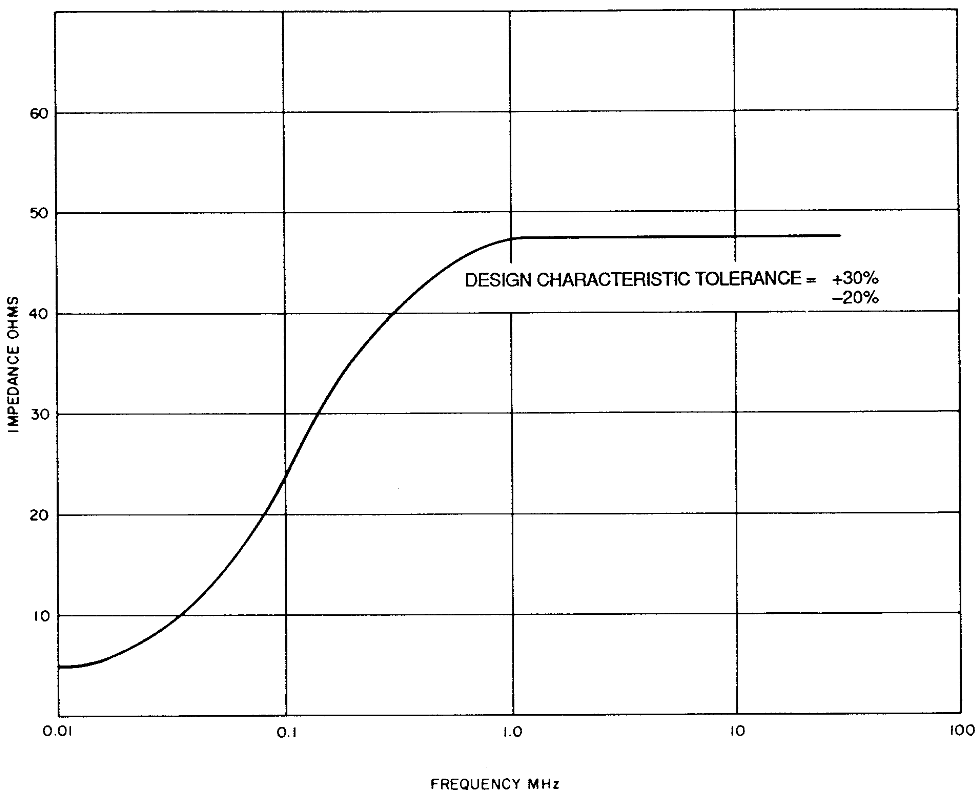
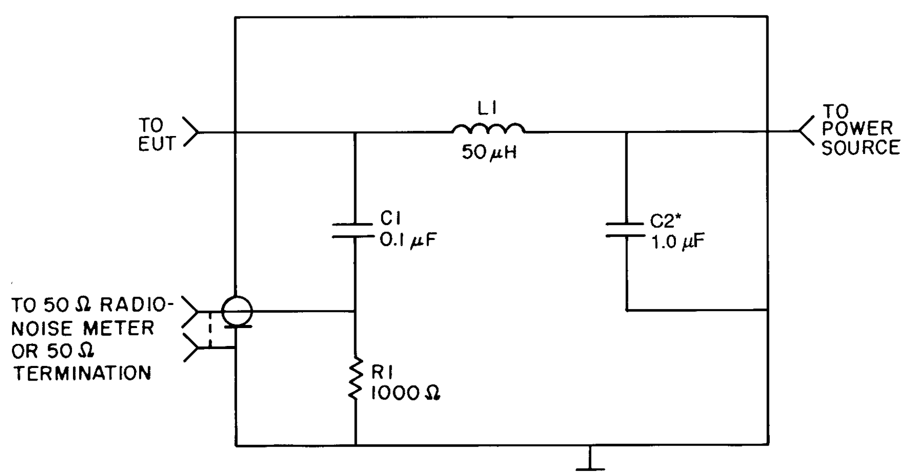


Fig 1— Impedance Characteristic of LISN at EUT Port 10 kHz to 30 MHz



*IN SOME LISNs, A SERIES RESISTANCE IS INCLUDED IN SERIES WITH CAPACITOR C2, E.G., CISPR PUBLICATION 16 (1987) [6].

Fig 2— Circuit Diagram of LISN to Provide Impedance of Fig 1 for the 0.15 MHz to 30 MHz Frequency Range

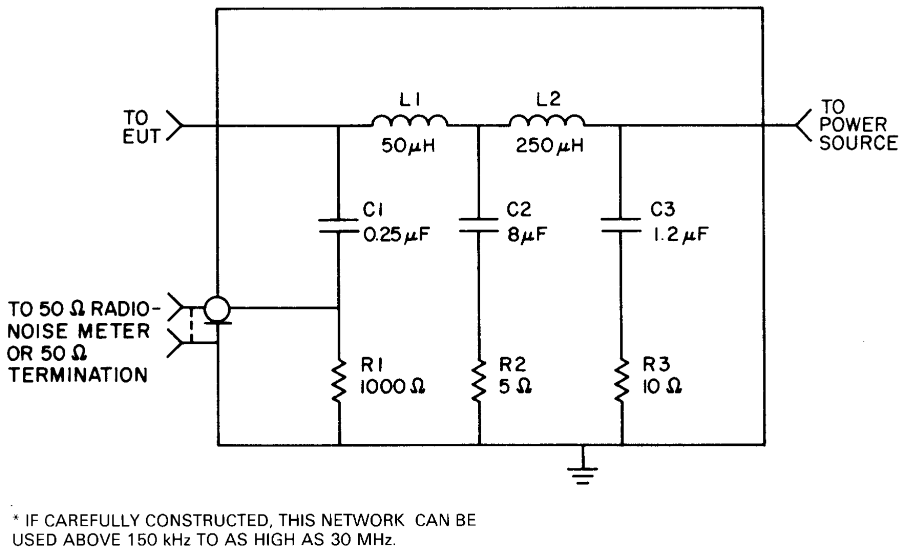


Fig 3— Circuit Diagram of LISN to Provide Impedance of Fig 1 for the 10 kHz to 150 kHz (3O MHz) Frequency Range

4.1.3 Voltage Probes

A voltage probe may be used for radio-noise voltage measurements when measurements are made at a user's installation (see 5.6) or when the ac current level exceeds the current-carrying capability of commercially available LISNs. For such measurements, the method shown in Fig 4 may be used. Special precautions shall be taken to establish a reference ground for the measurements. An LISN shall not be used in conjunction with a voltage probe for measurements at a user installation. The measurements are dependent on the impedance presented by the supply mains and may vary with time and location due to variations in the supply mains. (It may be necessary to perform repeated measurements over a suitable period of time to determine the variation in measured values. The time period shall be sufficient to cover all significant variations due to operating conditions at the installation.) Such measurement results shall be regarded as unique to that EUT and installation environment. The measurements shall be made between each current-carrying conductor in the supply mains and the ground conductor with a blocking capacitor (C) and a resistor (R), shown in Fig 4, such that the total resistance between line and ground is 1500 Ω. Since the voltage probe attenuates the radio-noise voltage, appropriate calibration factors shall be added to the measured values. Measurements made with LISNs shall take precedence over measurements made with voltage probes.

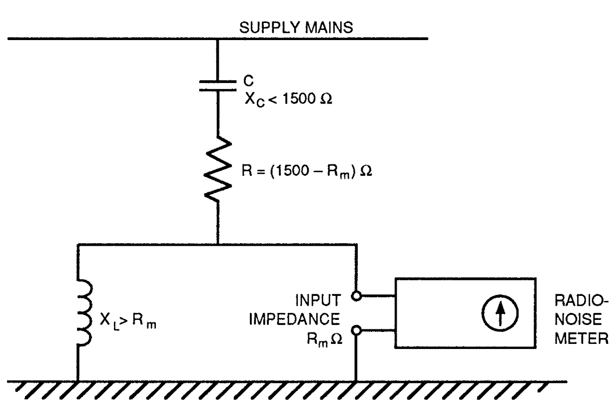


Fig 4— Voltage Probe for Tests at User's Installation

4.1.4 Current Probes

A current probe that fits around each current-carrying conductor under test may be used, when permitted, to measure radio-noise currents (in lieu of radio-noise voltages) generated by the EUT. The probe shall be immune to external fields, calibrated, and used with the proper terminating impedance. An LISN in accordance with 4.1.2 shall be inserted between the EUT conductors and the mains outlet. The probe is placed between the EUT and the LISN as near the LISN as possible. An appropriate adapter may be fitted between the EUT and the LISN to allow the current probe to be clamped on individual current-carrying conductors. If an appropriate LISN satisfying the current requirements of the EUT is not commercially available, the LISN may be eliminated and the current probe placed between the EUT and the mains outlet.

4.1.5 Antennas

The use of specific antennas depends on the frequency range and field (electric or magnetic) being measured in performing radiated emissions measurements as indicated in 4.1.5.1–4.1.5.4.

4.1.5.1 Magnetic Field Measurements (9 kHz to 30 MHz)

Calibrated loop antennas as specified in ANSI C63.2-1987 [1] shall be used to measure magnetic fields in the frequency range of 9 kHz to 30 MHz.

4.1.5.2 Electric Field Measurements (9 kHz to 30 MHz)

Calibrated monopole (rod) antennas as specified in ANSI C63.2-1987 [1] and IEEE Std 291-1991 [15] shall be used to measure electric fields in the frequency range of 9 kHz to 30 MHz. Generally, a 1.04 m (approximately 41 in) vertical monopole antenna is used with or without a counterpoise as specified by the manufacturer.

4.1.5.3 Electric Field Measurements (30 MHz to 1000 MHz)

Calibrated, linearly polarized antennas as specified in ANSI C63.2-1987 [1] shall be used to measure electric fields in the frequency range of 30 MHz to 1000 MHz. Tunable dipoles should be used. Alternatively, a linearly polarized broadband antenna or a dipole tuned only above 80 MHz, and set to the 80 MHz tuned length when used between 30 and 80 MHz, may be used in lieu of a tuned dipole provided that the measurement can be correlated with that made with a tuned dipole with an acceptable degree of accuracy. In case of dispute, data taken with a reference antenna or a tuned dipole calibrated in accordance with ANSI C63.5-1988 [2] shall take precedence.

4.1.5.4 Electric Field Measurements (1 to 40 GHz)

Calibrated, linearly polarized antennas as specified in ANSI C63.2-1987 [1] should be used. These include double-ridged guide horns, rectangular waveguide horns, pyramidal horns, optimum gain horns, and standard gain horns. The “beam” or major lobe of the pattern of any antenna used shall be large enough to encompass the EUT when located at the measuring distance, or provisions shall be made for “scanning” the EUT to locate the direction or source of its radiated emissions. The aperture dimensions of these horn antennas shall be small enough that the measurement distance in meters is equal to or greater than the Rayleigh Distance, i.e., $R_m = D^2 / (2\lambda)$, where D is the largest dimension of the aperture in meters of the antenna, and λ is the free-space wavelength in meters at the frequency of measurement. In case of dispute, measurements made with the standard gain horn antenna shall take precedence.

NOTE — Any calibrated, linearly polarized antenna, e.g., a lag-periodic dipole array may be used to make these measurements. The gain of many antennas, other than horn antennas, in this frequency range may be inadequate if the antennas are used with spectrum analyzers or older radio-noise meters. The tester shall assure that the overall measurement sensitivity is at least 6 dB below the applicable limit at the measurement distance in use, and that any means used to improve sensitivity, e.g., a preamplifier, does not cause distortion, spurious signals, or other overload problems, Since a log-periodic dipole array has a much wider beam width than a horn antenna, reflections from the ground plane may cause significant error in measurements that are made with a log-periodic dipole array. The tester shall assure that these reflections do not adversely affect the measured value.

4.1.6 Absorbing Clamp

Measurements of radio-noise power, if required, are made with an absorbing clamp (see Section 9).

4.2 Detector Function/Selection of Bandwidth

Unless otherwise specified, radio-noise meters or spectrum analyzers shall have as the reference detector function the quasi-peak detector specified in ANSI C63.2-1987 [1] for frequencies up to and including 1 GHz. For measurements above 1 GHz, if peak or average detectors are specified, use the C63.2-1987 requirements. Detector functions other than those specified by the procuring or regulatory agency may be used for making such measurements, provided (1) data so taken are correlatable to data taken with the appropriate detector and the associated instrument bandwidth, or (2) peak detector measured data may be substituted for the appropriate detector data to show compliance if the peak level obtained does not exceed the limit. The bandwidth used shall be equal to or greater than that specified in ANSI C63.2-1987. The bandwidth used shall be equal to or greater than 100 Hz from 9 kHz to 150 kHz, 9 kHz from 150 kHz to 30 MHz, 100 kHz from 30 MHz to 1000 MHz, and 1 MHz from 1 GHz to 40 GHz.

The measuring instrument shall satisfy the following conditions:

1) The measuring instrumentation with either the quasi-peak, peak, or average detector shall have a linear response.
2) When measuring an emission with a low duty cycle, the dynamic range of the measuring instrument shall not be exceeded.

NOTE — Use of bandwidths greater than those specified may produce higher readings for certain types of emissions.

4.3 Receiver Monitoring

All radio-noise measurements shall be monitored using either a head-set, a loudspeaker, a spectrum display, or any combination thereof as an aid to detecting ambient signals and selecting the emissions that have the highest amplitude relative to the limit. Precautions shall be taken to ascertain that the use of a headset or speaker does not affect the measuring instrument indication during measurements.

4.4 Calibration of Measuring Equipment

The calibration of the instrumentation shall be checked frequently to assure its accuracy in accordance with requirements of ANSI C63.2-1987 [1]. Adjustments shall be made and correction factors applied in accordance with instructions contained in the instruction manual of the equipment. Normally a direct reading measurement method is preferred. However, signal substitution methods may be used provided it can be established that the results are equivalent to a properly calibrated direct reading method.

In addition to the measuring instrumentation, cables, antennas, LISNs, voltage and current probes, etc., and the test facility are to be checked and calibrated as necessary on a regular basis to ensure the accuracy of the test results, but no less frequently than annually.

As a minimum, all instrumentation shall be calibrated using secondary standards traceable to the National Institute of Standards and Technology (NIST) or an equivalent standards reference organization. An example of a satisfactory calibration system is given by MIL-STD-45662 [17].

4.4.1 Antenna Calibration

All antennas shall be individually calibrated to show traceability to NIST or an equivalent standards reference organization. Antennas calibrated by the methods given in ANSI C63.5-1988 [2] meet the traceability requirements.

Antenna factors shall be rechecked at least once a year, by recalibration techniques or by checking against reference antennas or known signal sources. Spot-checking during the period between calibrations is recommended.

Reference antennas that are used only for calibration or comparison purposes and not used on a daily basis should be recalibrated at least every three years.

Antennas for use below 30 MHz shall be calibrated using an acceptable method, such as one of the methods in IEEE Std 291-1991 [15].

Antennas for use from 30 to 1000 MHz shall be calibrated using one of the methods specified in ANSI C63.5-1988 [2]. Reference antennas shall be constructed as specified therein. It is strongly recommended that the reference antenna be spot-checked against other known antennas. If adjustable (tunable) dipole antennas are used below 80 MHz while set at their 80 MHz resonant length, they shall also be calibrated at that length for the range of frequencies of use according to ANSI C63.5-1988.

Antennas for use at or above 1 GHz shall be calibrated using an acceptable method, such as one of the methods in IEEE Std 291-1991 [15] or IEEE 149-1979 [12]. The antenna used shall be calibrated at the measuring distance at which it will be used.

NOTES:

1 — If the antenna is calibrated at a distance $\geq 2.D^2/\lambda$, it may be used to make measurements at any distance greater than $2.D^2/\lambda$ with an error of less than 1 dB.

2 — Gain standard horn antennas (sometimes called standard gain horn antennas) need not be calibrated beyond that which is provided by the manufacturer unless (a) they are damaged or deterioration is suspected, or (b) they are used at a distance closer than $2.D^2/\lambda$. Gain standard horn antennas have gains that are fixed by their dimensions and dimensional tolerances.

4.4.2 LISN Calibration

The impedance and insertion loss of each LISN used in testing for conducted emissions is to be measured over the frequency range of use in accordance with the procedure described in Appendix F. LISN impedance shall be calibrated at least once a year, and frequent spot-checking is recommended. Where the LISN is permanently installed on a test site, calibration should be performed as required in 5.2.3.

4.4.3 Absorbing Cable Clamp Calibration

The absorbing cable clamp may be calibrated using the procedure in clause 11.3 of CISPR Publication 16 (1967) [6], much of which is summarized in Appendix G.

4.4.4 Cable Calibration

Cables used for connection of antennas or transducers to measuring instruments (radio-noise meters, spectrum analyzers, etc.) shall be calibrated for loss using an acceptable standard, such as IEEE Std 474-1973 [16], and checked frequently for deterioration caused by use and exposure to sunlight, physical wear, and other conditions.

5. Test Facilities

Radiated and ac powerline conducted measurements shall be made in an environment that assures valid, repeatable measurement results as described in 5.2 (ac powerline conducted emissions test sites) or 5.3, 5.4, and 5.5 (radiated emissions test sites). Where appropriate, tests may be made at the manufacturer's location or the user’s installation (5.6). In any case, the requirements of 5.1 shall be observed.

5.1 General Requirements

5.1.1 Power Source

Sufficient power shall be available to operate the EUT at its rated voltage, current, power, and frequency.

5.1.2 Ambient Radio Noise and Signals

AC powerline conducted and radiated ambient radio noise and signal levels, measured at the test site with the EUT de-energized, should be at least 6 dB below the allowable limit of the applicable specification or standard. In the event that the measured levels of ambient plus EUT radio noise are not above the applicable limit, the EUT shall be considered to be in accordance with the limit.

If the ambient field or the powerline ambient level exceeds the applicable limit(s), the following alternatives may be used:

1) In the case of radiated measurements, perform measurements at the closest distance permitted by 5.4.1 and extrapolate results to the specified limit distance. The method of extrapolation shall be justified and described in the test report.
2) Perform measurements of critical frequency bands during hours when broadcast stations are off the air and at times when ambients from industrial equipment are reduced to less than the 6 dB level.
3) Perform measurements in an absorber-lined room (see 5.4.2 for conditions of use).
4) Make ac powerline conducted measurements in a shielded enclosure. However, this method is recommended only at frequencies below the resonant frequencies of the enclosure, usually under 30 MHz.
5) For ac powerline conducted measurements, insert suitable powerline filters between the power source and the LISN.
6) Orient the test site so as to discriminate against such ambient signals insofar as possible.
7) If the signal being measured is narrowband and the ambient field is broadband, reduce the bandwidth of the receiver.
8) Rotate the EUT on a turntable while observing possible correlation between emission amplitude and EUT azimuth.
9) Monitor the radio-noise meter audio with a loudspeaker or headphones and its video with a time-based oscilloscope display to discriminate between ambient noise and signals and EUT emissions.

5.2 AC Powerline Conducted Emissions Test Site Requirements

AC powerline conducted measurements may be made at a site that meets the requirements of this section. This may include a shielded (screened) room or a radiated emissions test site.

5.2.1 Conducting Ground Plane

The conducting ground plane for measuring ac powerline conducted emissions is to consist of a floor earth-grounded conducting surface, which may be the metal floor of a shielded test chamber. The conducting surface is to be at least 2 m by 2 m in size, and shall extend at least 0.5 m beyond the vertical projection (footprint) of the EUT. Where the EUT normally does not make physical contact with a ground plane, the ground plane shall be covered by insulating materials between 3 mm and 12 mm thick.

5.2.2 Vertical Conducting Surface

For measurements of ac powerline conducted emissions on a tabletop device, a vertical conducting plane or screen of at least 2 m by 2 m in size shall be located 40 cm to the rear of the EUT. The conducting plane or screen shall be electrically connected to the conducting ground plane at intervals not greater than one meter along its entire length through low-impedance connection, e.g., 3 cm-wide metal straps. The metal wall of a screen room will normally satisfy this requirement.

For a tabletop device tested on an open area test site for ac powerline conducted emissions, a vertical conducting surface is optional. However, in case of a dispute, ac powerline conducted measurements made on a tabletop device with a vertical conducting surface in place shall take precedence.

A vertical conducting surface is not required for ac powerline conducted emissions measurements on a floor-standing device.

5.2.3 LISN Installation

Where use of an LISN is required (see Section 7), it shall be placed on the top surface of, or immediately beneath, the conducting ground plane and grounded to the plane.

The impedance at the EUT socket end of the LISN or the socket end of any cable connected to the EUT end of the LISN, with the measuring instrument port of the LISN terminated in 50 Ω, shall be within +30% and –20% of the nominal LISN impedance shown in Fig 1 over the frequency range of the network to be used. If the attenuation (insertion loss) between the EUT plug and the measuring instrument port on the LISN is more than 0.5 dB, it shall be taken into account when calculating the EUT emission levels. The site ground plane is the ground reference for the LISN.

Ambient noise may be present on the ac power mains at some locations at some frequencies within the range of measuring interest. If the levels are sufficient to cause interference with readings made using an LISN, filtering of the ac mains may be required. The filter should be inserted between the ac mains supply and the ac input connection to the LISN, preferably as close as possible to the LISN to reduce interference pickup by the leads between the filter and the LISN. The LISN impedance shall be rechecked if an ac mains filter is used.

Where an isolation transformer is used between the ac mains supply and the LISN, care must be taken to ensure that this transformer's rating is large enough to not affect the peak current drawn by the EUT (this may require ten times the kVA rating of the EUT). If other than air core inductors are used in the LISN, they shall be in a linear permeability range at the peak currents drawn by the EUT.

5.2.4 Voltage Probe

Where use of an LISN is impossible due to high current requirements of the EUT, or where a conducting ground plane is not available, conducted emissions tests shall be performed using the voltage probe as discussed in 4.1.3. See also 5.6.

5.3 Radiated Emissions Test Site Requirements for Measurements Below 30 MHz

For magnetic field strength measurements (see 8.2.1), a site similar to that of Fig 5 should be used except that a conducting ground plane is not required. If a conducting ground plane is present, the measured level of emissions may be higher. Magnetic field strength measurements made at a site with no conducting ground plane shall take precedence. If permitted by the procuring or regulatory agency, measurements may be made in a shielded enclosure at frequencies below its resonant frequency.

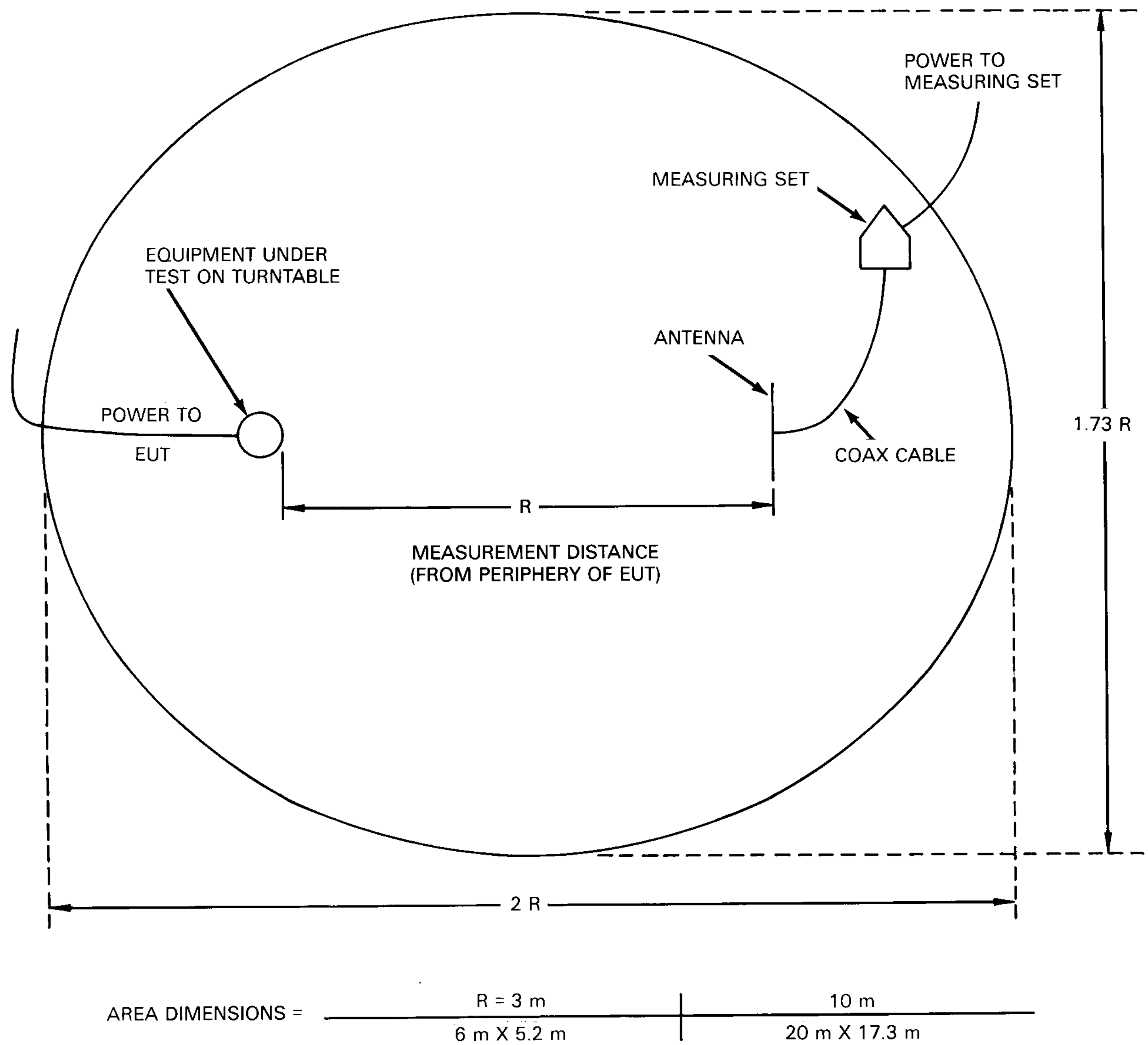


Fig 5— Radiated Emissions Measurement Obstruction-Free Area for Site with a Turntable

5.4 Radiated Emissions Test Site Requirements for Measurements 30 MHz to 1 GHz

Test sites used for making final radiated emissions tests shall be capable of meeting the applicable requirements given in 5.4.6.

5.4.1 Reference Test Site

The reference site for radiated tests is an open, flat area (open area test site) characteristic of cleared, level terrain. Such a site shall be void of buildings, electric lines, fences, trees, underground cables, pipelines, etc., except as required to perform the test. A suggested layout of an open area test site is shown in Fig 5, where the recommended distance for *R* (measured from the nearest perimeter of the EUT) is 3, 10, or 30 m. All reflecting objects including test personnel shall lie outside the perimeter of the ellipse. ANSI C63.7-1988 [4] further describes the characteristics and construction of open area test sites. A conducting ground plane is required (see 5.4.3).

5.4.2 Alternate Test Sites

Measurements can be made at a location other than an open area test site, such as a weather-protected site, an absorber-lined room, a dedicated laboratory, or a factory site provided the alternate site meets the site attenuation requirements of 5.4.6 over the volume occupied by the EUT (see 5.4.6.5) and the conducting ground plane requirements of 5.4.3. For the time being, weather-protected sites are exempt from the requirements to meet 5.4.6.5, as this matter is under study (see Appendix C). Measurements can also be made where the requirements of 5.4.6 are not met but it can be demonstrated to the relevant authority that the results achieved are equivalent to those obtained at an open area test site over the frequency range at which measurements are made. In cases of disagreement, final radiated emissions tests performed at an open area site meeting the requirements of 5.4.1 and 5.4.6 take precedence.

5.4.2.1 Shielded Enclosures

A shielded enclosure not containing absorber lining may be used only for preliminary testing (see 8.3.1.1).

5.4.3 Conducting Ground Plane

A conducting ground plane is required at a radiated emissions test site. The conducting ground plane shall extend at least 1 m beyond the periphery of the EUT and the largest measuring antenna, and cover the entire area between the EUT and the antenna. It shall be of metal with no holes or gaps having longitudinal dimensions larger than one-tenth of a wavelength at the highest frequency of measurement up to 1 GHz (ANSI C63.7-1988 [4]). A larger size conducting ground plane may be required if the test site has any of the following characteristics

1) The terrain of the site is discontinuous.
2) The terrain of the site is subject to extreme seasonal variations in ground conductivity.
3) There are unburied power or control cables on the site.
4) The site is located on pavement.
5) The site is raised or located on a rooftop or otherwise elevated above the surrounding in situ ground.
6) Test site does not meet site attenuation requirements.

NOTE — Ongoing studies may indicate the need for specifying a minimum conducting ground plane size.

5.4.4 Turntable

A continuously rotatable turntable shall be used for measuring radiated emissions from all sides of the EUT. It is strongly recommended that this turntable be remotely controlled to prevent test personnel from coming into close proximity to the EUT and thus affecting test results (See NOTE 1 below). For floor-standing EUTs, the turntable shall be metal-covered and flush with the conducting ground plane (NOTE 2). Table-mounted EUTs shall be tested by using a nonmetallic table of correct height mounted on top of the flush-mounted conductive turntable. A combination of a raised nonmetallic turntable and nonmetallic table located on top of the conducting ground plane may also be acceptable. Site attenuation measurements according to 5.4.6 shall be made to show if such combinations meet requirements. The site attenuation measurement should also show whether the gap between a conducting flush turntable circumference and the surrounding conducting ground plane should be electrically bridged with suitable rubbing or rolling flexible conductive material. The presence of such electrical connection can be temporarily simulated by bridging the circumferential gap with conductive tape and conductive adhesive at least every 30°. If there is no change in site attenuation, especially below 100 MHz for vertical polarization measurements, the gap need not be filled. If noticeable changes are observed, i.e., a change of approximately 1 dB or more, a suitable bridging mechanism as mentioned above should be installed. See ANSI C63.7-1988 [4] for further guidance.

For some applications, such as operation of the EUT via a remotely located simulator and I/O cabling, the turntable should have a center opening that will allow cabling to be routed directly down to the conducting ground plane for raised turntables or below the conducting ground plane for flush turntables (NOTE 3).

NOTES:

1 — If a remotely controlled turntable is not used for final radiated emissions measurements, the measurement report shall include information to demonstrate how the influence of the tester's body was eliminated from radiated emissions test results.

2 — Because of their present rather extensive use, raised turntables not exceeding 34 cm in height may be used until January 17, 1994, for measuring floor-standing equipment. If a raised turntable is used, the conducting ground plane shall be continuous beneath the turntable. Material used for such turntables should be selected so that there is no adverse effect when performing the site attenuation measurement. Because it is generally agreed that measured levels are dependent on equipment height, in case of dispute, measurements made with a flush-mounted turntable shall take precedence.

3 — If the center area does not rotate with the turntable, power and cooling access and receptacles can also be accommodated and supplied from below the top of the turntable.

5.4.5 Antenna Positioner

The antenna positioner used to position the measurement antenna for the radiated emissions measurements shall be capable of positioning the center of the antenna at any height in the range of 1 to 4 m above the ground plane. The positioner shall be capable of maintaining the antenna in both the horizontal and vertical polarizations. The positioner shall be in place and used for the support of the receiving antenna during site attenuation measurements.

To meet site attenuation requirements usually requires that the positioner and all antenna-mounting adapters be constructed of substantially nonreflecting materials such as wood, plastic, nylon, or fiberglass. Any antenna positioner components containing substantial amounts of metal, such as the motor, base assembly or wheels, should be mounted as close to the ground plane as practical.

5.4.6 Validation Requirements

Radiated emissions test sites shall be validated by making both horizontal and vertical normalized site attenuation (NSA) measurements. Antenna spacings used for making site attenuation measurements shall be the same as the spacing used for the EUT compliance tests at frequencies from 30 to 1000 MHz. The measured NSA data shall be compared to that calculated for an ideal site.

NOTE — During site attenuation measurements, the receiving antenna positioner normally used and raised turntable, if used, shall be in place.

5.4.6.1 Site Attenuation

A measurement site shall be considered acceptable for radiated electromagnetic field measurements if the horizontal and vertical NSA derived from measurements, i.e., the “measured NSA,” are within ±4 dB of the theoretical NSA (5.4.6.3) for an ideal site.

5.4.6.2 NSA Tolerance

The ±4 dB tolerance in 5.4.6.1 includes instrumentation calibration errors, measurement technique errors, and errors due to site anomalies. These errors are analyzed in ANSI C63.6-1988 [3], wherein it is shown that the performance of a well-built site contributes only 1 dB of the total allowable tolerance. Appendix C of this document suggests actions to be taken if a site fails to meet the requirements.

5.4.6.3 Theoretical NSA

The theoretical NSAs for the most used measurement separations and antennas are shown in Tables 1 through 3, for an ideal site.

The theoretical NSA is developed and calculated in [B15]. Tables 1 through 3 are from [B9], [B11], [B14], and [B15]. The mutual impedance correction factors for tuned dipole antennas were developed in [B15] and have subsequently been revised in [B9] and [B14] and are shown in Table 4. The symbols for these tables are defined as follows:

R = Horizontal separation between the projection of the transmit and receive antennas on the conducting ground plane (meters)
h_1 = Height of the center of the transmitting antenna above the conducting ground plane (meters)
h_2 = Height of the center of the receiving antenna above the conducting ground plane (meters)

NOTE — In the measurement procedure, h_2 is varied and the maximum received signal in the height scan range is used in the NSA measurements. f_M = frequency in MHz, A_N = NSA (see Eq 1).

Table 1 is used for broadband antennas such as biconical and log periodic arrays. Table 2 is for tunable dipoles (and broadband antennas for alternate test site qualification) aligned horizontally with respect to the conducting ground plane. Finally, Table 3 is for tunable dipoles, vertically aligned with respect to the conducting ground plane. Note that in Table 3, there are restrictions in the scan height h_2. This takes into account the fact that the lowest tip of the receive dipole is kept 25 cm or more from the conducting ground plane.

NSA for frequencies other than those shown in the tables may be found using straight-line interpolation between the tabulated values.

NOTE — The spacing R between log-periodic array antennas is measured from the projection onto the conducting ground plane of the midpoint of the longitudinal axis of each antenna.

5.4.6.4 NSA Measurement: Basic Procedures

Two antennas are set up on the test site in an appropriate geometry as shown in Figs 6 and 7. The NSA procedure requires two different measurements of the voltage received, V_R. The first reading of V_R is with the two coaxial cables disconnected from the two antennas and connected to each other via an adapter. The second reading of V_R is taken with the coaxial cables reconnected to their respective antennas and the maximum signal measured with the receive antenna scanned in height [B12]. For both of these measurements, the signal source, V_I, is kept constant. The first reading of V_R is called V_{Direct} and the second is V_{Site}. These are used in the following Eq 1 for the measured NSA, A_N; all terms are in dB.

$$A_N = V_{\text{Direct}} - V_{\text{Site}} - AF_T - AF_R - \Delta AF_{TOT} \tag{Eq1}$$

where

AF_T = Antenna factor of transmitting antenna
AF_R = Antenna factor of receiving antenna
AF_{TOT} = Mutual impedance correction factor

NOTE — The first two terms represent the actual measurement of site attenuations; i.e., $V_{\text{Direct}} - V_{\text{Site}}$ is equal to the classical site attenuation and

$$V_{\text{Direct}} = V_I - C_T - C_R \tag{Eq2}$$

where C_T and C_R are the cable losses that do not need to be measured separately.

AF_T and AF_R are determined as specified in ANSI C63.5-1988 [2]. The mutual impedance correction factor in Table 4 applies only to the recommended site geometry of 3 m separation, both horizontal and vertical polarization, with the use of resonant tuned dipoles. ΔAF_{TOT} = 0 for all other geometries and for broadband antennas.

Table 1— Theoretical Normalized Site Attenuation for Ideal Site (Recommended Geometries for Broadband Antennas)*

Polarization	**Horizontal**	**Horizontal**	**Horizontal**	**Vertical**	**Vertical**	**Vertical**	**Vertical**	**Vertical**	**Vertical**
***R* meters**	**3**	**10**	**30**	**3**	**3**	**10**	**10**	**30**	**30**
h_1 meters	**1**	**1**	**1**	**1**	**1.5**	**1**	**1.5**	**1**	**1.5**
h_2 meters	**1–4**	**1–4**	**1–4**	**1–4**	**1–4**	**1–4**	**1–4**	**1–4**	**1–4**
f_M (MHz)		**A_N(dB)**							
30	15.8	29.8	47.7	8.2	9.3	16.7	16.8	26.0	26.0
35	13.4	27.1	45.0	6.9	8.0	15.4	15.5	24.7	24.7
40	11.3	24.9	42.7	5.8	7.0	14.2	14.4	23.5	23.5
45	9.4	22.9	40.7	4.9	6.1	13.2	13.4	22.5	22.5
50	7.8	21.1	38.8	4.0	5.4	12.3	12.5	21.6	21.6
60	5.0	18.0	35.7	2.6	4.1	10.7	10.9	20.0	20.0
70	2.8	15.5	33.0	1.5	3.2	9.4	9.6	18.7	18.7
80	0.9	13.3	30.7	0.6	2.6	8.3	8.5	17.5	17.5
90	–.7	11.4	28.7	–0.1	2.1	7.3	7.6	16.5	16.5
100	–2.0	9.7	26.9	–0.7	1.9	6.4	6.8	15.6	15.6
120	–4.2	7.0	23.8	–1.5	1.3	4.9	5.4	14.0	14.0
125	–4.7	6.4	23.1	–1.6	0.5	4.6	5.1	13.6	13.7
140	–6.0	4.8	21.1	–1.8	–1.5	3.7	4.3	12.7	12.7
150	–6.7	3.9	20.0	–1.8	–2.6	3.1	3.8	12.1	12.1
160	–7.4	3.1	18.9	–1.7	–3.7	2.6	3.4	11.5	11.6
175	–8.3	2.0	17.4	–1.4	–4.9	2.0	3.1	10.8	10.8
180	–8.6	1.7	16.9	–1.3	–5.3	1.8	2.7	10.5	10.6
200	–9.6	0.6	15.2	–3.6	–6.7	1.0	2.1	9.6	9.7
250	–11.7	–1.6	11.6	–7.7	–9.1	–0.5	0.3	7.7	7.9
300	–12.8	–3.3	8.7	–10.5	–10.9	–1.5	–1.9	6.2	6.4
400	–14.8	–5.9	4.5	–14.0	–12.6	–4.1	–5.0	3.9	4.3
500	–17.3	–7.9	1.8	–16.4	–15.1	–6.7	–7.2	2.1	2.8
600	–19.1	–9.5	0.0	–16.3	–16.9	–8.7	–8.9	0.8	1.8
700	–20.	–10.8	–1.3	–18.4	–18.4	–10.2	–10.3	–0.3	–0.8
800	–21.3	–12.0	–2.5	–20.0	–19.3	–11.5	–11.6	–1.1	–2.2
900	–22.5	–12.8	–3.5	–21.3	–20.4	–12.6	–12.6	–1.7	–3.3
1000	–23.5	–13.8	–4.5	–22.4	–21.4	–13.6	–13.6	–3.6	–4.3

none These data apply to antennas that have at least 25 cm of ground plane clearance when the center of the antenna is 1 m above the ground plane in vertical polarization.

Table 2— Theoretical Normalized Site Attenuation for Ideal Site (Recommended Geometries for Tunable Dipoles and for Broadband Antennas on Alternate Test Sites, Horizontal Polarization)

Polarization	Horizontal	Horizontal	Horizontal
R meters	3*	10	30
h_1 meters	2	2	2
h_2 meters	1–4	1–4	1–4
f_M	A_N (dB)	A_N (dB)	A_N (dB)
30	11.0	24.1	41.7
35	8.8	21.6	39.1
40	7.0	19.4	36.8
45	5.5	17.5	84.7
50	4.2	15.9	32.9
60	2.2	13.1	29.8
70	0.6	10.9	27.2
80	–4.7	9.2	24.9
90	–1.8	7.8	23.0
100	–2.8	6.7	21.2
120	–4.4	5.0	18.2
125	–4.7	4.6	17.6
140	–5.8	3.5	15.8
150	–6.3	2.9	14.7
160	–6.7	2.3	13.8
175	–6.9	1.5	12.4
180	–7.2	1.2	12.0
200	–8.4	0.3	10.6
250	–10.6	–1.7	7.8
300	–12.3	–3.3	6.1
400	–14.9	–5.8	3.5
500	–16.7	–7.6	1.6
600	–18.3	–9.3	0.0
700	–19.7	–10.6	–1.4
800	–20.8	–11.8	–2.5
900	–21.8	–12.9	–3.5
1000	–22.7	–13.8	–4.5

*The mutual impedance correction factors in Table 4 for horizontally polarized tunable dipoles spaced 3 m apart should be inserted in Eq 1 of 5.4.6.4 in determining the measured NSA data for comparison with the theoretical normalized site attenuation values for an ideal site given in this table.

Table 3— Theoretical Normalized Size Attenuation for Ideal Site (Recommended Geometries for Tunable Dipoles, Vertical Polarization)

f_M	R = 3m*		R = 10m		R = 30m	
MHz	h_1 = 2.75 m		h_1 = 2.75 m		h_1 = 2.75 m	
	h_2 (m)	A_N (dB)	h_2 (m)	A_N (dB)	h_2 (m)	A_N (dB)
30	2.75–4	12.4	2.75–4	18.8	2.75–4	26.3
35	2.39–4	11.3	2.39–4	17.4	2.39–4	24.9
40	2.13–4	10.4	2.13–4	16.2	2.13–4	23.8
45	1.92–4	9.5	1.92–4	15.1	1.92–4	22.7
50	1.75–4	8.4	1.75–4	14.2	1.75–4	21.8
60	1.50–4	6.3	1.50–4	12.6	1.50–4	20.2
70	1.32–4	4.4	1.32–4	11.3	1.32–4	18.9
80	1.19–4	2.8	1.19–4	10.2	1.19–4	17.7
90	1.08–4	1.5	1.08–4	9.2	1.08–4	16.7
100	1–4	0.6	1–4	8.4	1–4	15.8
120	1–4	–0.7	1–4	7.5	1–4	14.3
125	1–4	–0.9	1–4	7.3	1–4	14.0
140	1–4	–1.5	1–4	5.5	1–4	13.0
150	1–4	–2.0	1–4	4.7	1–4	12.5
160	1–4	–3.1	1–4	3.9	1–4	12.0
175	1–4	–4.1	1–4	3.0	1–4	11.3
180	1–4	–4.5	1–4	2.7	1–4	11.1
200	1–4	–5.4	1–4	1.6	1–4	10.3
250	1–4	–7.0	1–4	–0.6	1–4	8.7
300	1–4	–8.9	1–4	–2.3	1–4	7.6
400	1–4	–11.4	1–4	–4.9	1–4	3.9
500	1–4	–13.4	1–4	–6.9	1–4	1.8
600	1–4	–14.9	1–4	–8.4	1–4	0.2
700	1–4	–16.3	1–4	–9.7	1–4	–1.2
800	1–4	–17.4	1–4	–10.9	1–4	–2.4
900	1–4	–18.5	1–4	–12.0	1–4	–3.4
1000	1–4	–19.4	1–4	–13.0	1–4	–4.3

*The mutual impedance correction factors in Table 4 for vertically polarized tunable dipoles spaced 3 m apart should be inserted in Eq 1 of 5.4.6.4 in determining the measured NSA data for comparison with the theoretical NSA values for an ideal site given in this table.

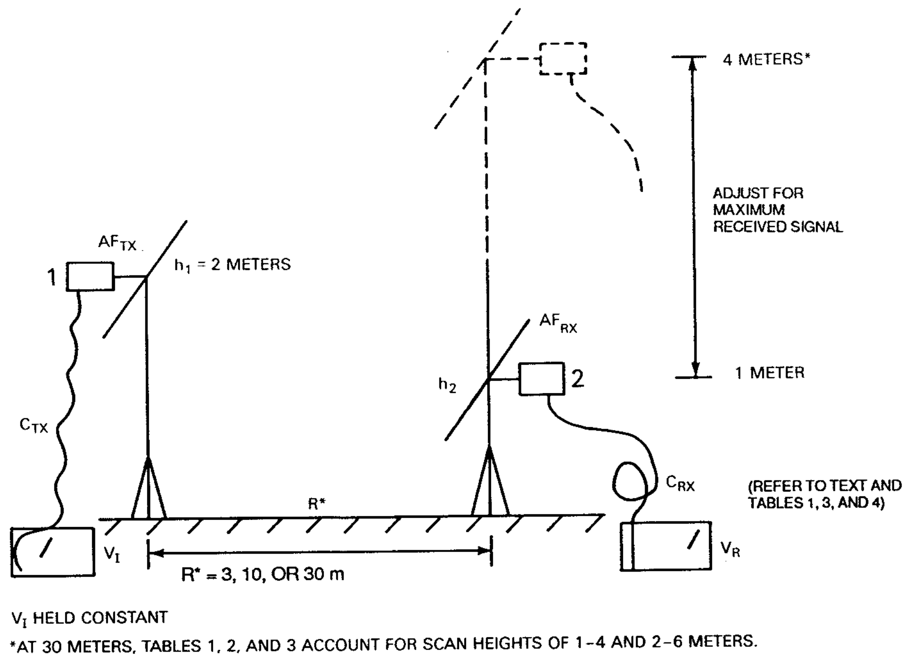


Fig 6— Site Attenuation Measurement Horizontal Polarization, Broadband and Tuned Dipoles

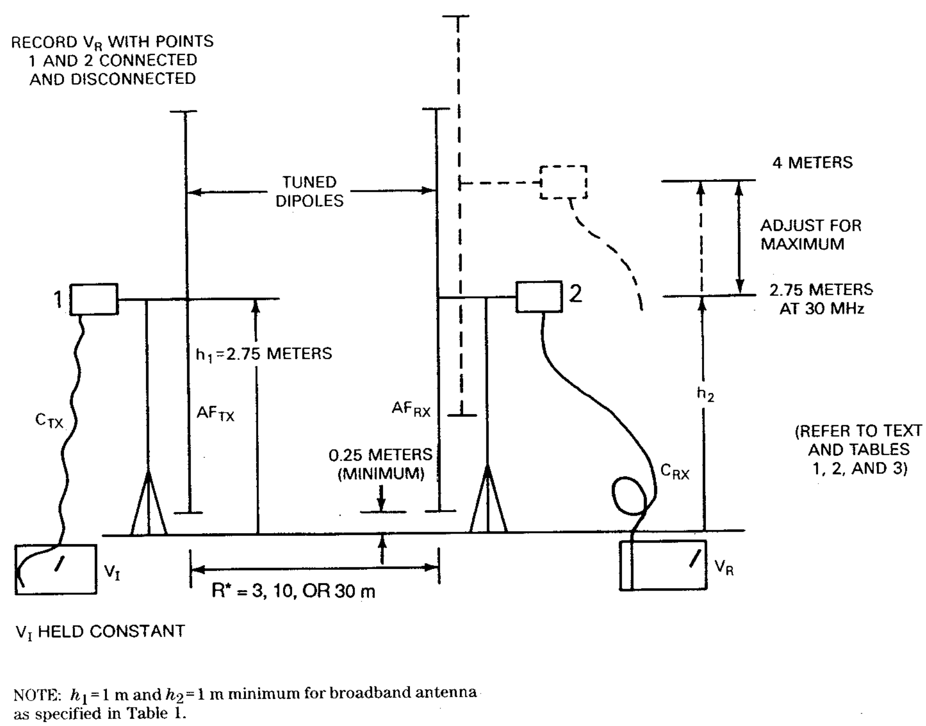


Fig 7— Site Attenuation Measurement Vertical Polarization Using Tuned Dipole Antennas

Table 4— Mutual Impedance Correction Factors (ΔAF_{TOT}) for Geometry Using Two Resonant Tunable Dipoles Spaced 3 m Apart

	Horizontal Pol R = 3m h_1 = 2m h_2 = 1 to 4 m Scan	Vertical Pol R = 3 m h_1 = 2.75 m h_2 = (see Table 3)
f_M MHz	ΔAF_{TOT}	
30	3.1	2.9
35	4.0	2.6
40	4.1	2.1
45	3.3	1.6
50	2.8	1.5
60	1.0	2.0
70	–0.4	1.5
80	–1.0	0.9
90	–1.0	0.7
100	–1.2	0.1
120	–0.4	–0.2
125	–0.2	–0.2
140	–0.1	0.2
150	–0.9	0.4
160	–1.5	0.5
175	–1.8	–0.2
180	–1.0	–0.4

NOTE — Calculated for resonant dipoles with reference antenna baluns using Method of Moments (NFPA 70-1990, National Electrical Code).
Theoretical free-space antenna factors are for ideal resonant dipoles with an assumed 0.5 dB balun loss (each antenna). If the actual balun loss is known, it should be used to provide an appropriate modification to each antenna factor used in arriving at the correction factors in this table. See Reference Antenna in ANSI C63.5-1988 [2]. These correction factors do not completely describe antenna factors measured above a ground plane, e.g., at heights of 3 or 4 m, since these antenna factors differ from free-space antenna factors at the lower frequencies. However, within the error, and for baluns with substantially different loss than 0.5 dB, hounds described in ANSI C63.6-1988 [3], the values are adequate to indicate site anomalies.
User is cautioned when using half-wavelength dipoles or antennas with other than reference antenna baluns. These may exhibit characteristics different than the reference antenna.
Mutual coupling correction factors for 10 and 30 m are under consideration. As an interim procedure, site adequacy can be assessed by considering these correction factors to be equal to zero for such geometries and for all measurements using broadband antenna.

Accurate antenna factors are necessary in determining the measured NSA. In general, antenna factors provided with the antenna are inadequate unless they were specifically or individually measured and the calibration is traceable to a national standard. Linearly polarized antennas are required. ANSI C63.5-1988 [2] contains a design of a reference antenna and methods for calibrating antennas. The reference dipole antenna (4.1.5.3) should be spot-checked against a known calibrated antenna. Antenna factors usually account for losses due to the balun. If a separate balun or any integrally associated cables are used, their effects shall be accounted for.

Two procedures may be employed to determine the measured NSA: a discrete frequency method and a swept frequency method. The swept method may be used only with broadband antennas. Figure 6 shows the horizontal polarization geometry. In Fig 7, the recommended vertical polarization geometries for using tunable resonant half-wave dipoles are shown. This assumes that the dipoles are tuned down to 30 MHz. The limiting factor of maintaining at least a 25 cm clearance between the lower tip of the receive and transmit antennas is covered by (1) fixing the transmit height at 2.75 m, and (2) restricting the downward travel of the receive antenna. These restrictions are stated explicitly in Table 3. For vertical NSA measurements with broadband antennas, no such scan height restrictions are required due to the much smaller fixed dimensions of a broadband antenna compared to a tuned dipole, especially between 30 and 80 MHz. Using linearly polarized broadband antennas also allows a transmit antenna height of 1 m.

NOTES:

1 — For both methods, an impedance mismatch at the output of the signal source or at the input of the radio-noise meter or spectrum analyzer may result in cable reflections that could cause errors exceeding the NSA tolerance. This can be avoided by use of padding attenuators of 10 dB; one at the output end of each transmitting and receiving cable. These attenuators shall remain in the cables for both V_{Direct} and V_{Site} measurements.

2 — Attenuator values of 6 dB are often adequate and values as low as 3 dB can sometimes be used.

For the discrete frequency method, specific frequencies given in Tables 1, 2, and 3 are measured in turn. At each frequency the receive antenna is moved over the height range given in the appropriate table to maximize the received signal. These measured parameter values are inserted in Eq 1 to obtain the measured NSA. Appendix A contains a suggested procedure involving a worksheet approach to record the data, calculate the measured NSA, and then compare it with the theoretical NSA.

For the swept frequency method, measurements using broadband antennas may be made using automatic measuring equipment having a peak hold (maximum hold) storage capability and a tracking generator. In this method both antenna height and frequency are scanned or swept over the required ranges. The frequency sweep speed shall be much greater than the antenna height scan rate. Otherwise the procedure is the same as in the previous paragraph. A detailed procedure is given in Appendix B.

5.4.6.5 NSA for Alternate Test Sites

For an alternate test site (see 5.4.2) a single-point NSA measurement is insufficient to pick up possible reflections from the construction and/or RF-absorbing material comprising the walls and ceiling of the facility. For these sites, a “test volume” is defined as that volume traced out by the largest equipment or system to be tested as it is rotated about its center location through 360°, such as by a turntable. In evaluating the site, the transmit antenna shall be placed at various points within the test volume with both horizontal and vertical polarization, such as illustrated in Figs 8(a) and 8(b) [B10]. This may require a maximum of 20 separate site attenuation measurements, i.e., five positions in the horizontal plane (center, left, right, front, and rear, measured with respect to the center and a line drawn from the center to the position of the measuring antenna), for two polarizations (horizontal and vertical), and for two heights (1 and 2 m, horizontal) (1 and 1.5 m, vertical).

These measurements are carried out with a broadband antenna and distances are measured with respect to the center of the antenna. The transmit and receive antennas shall be aligned with the antenna elements parallel to each other and orthogonal to the measurement axis.

For vertical polarization, the off-center positions of the transmit antenna are at the periphery of the test volume. Furthermore, the lower tip of the antenna shall be greater than 25 cm from the floor, which may require the center of the antenna to be slightly higher than 1 m for the lowest height measurement.

For horizontal polarization measurements in the left and right positions if the distance between the construction and/or absorbing material on the side walls and the EUT periphery is at least 1 m, the center of the antenna is moved towards the center position so that the extreme tip of the antenna is either at the periphery or at a distance from the periphery by not more than 10% of the test volume diameter. The front and rear positions are at the periphery of the test volume.

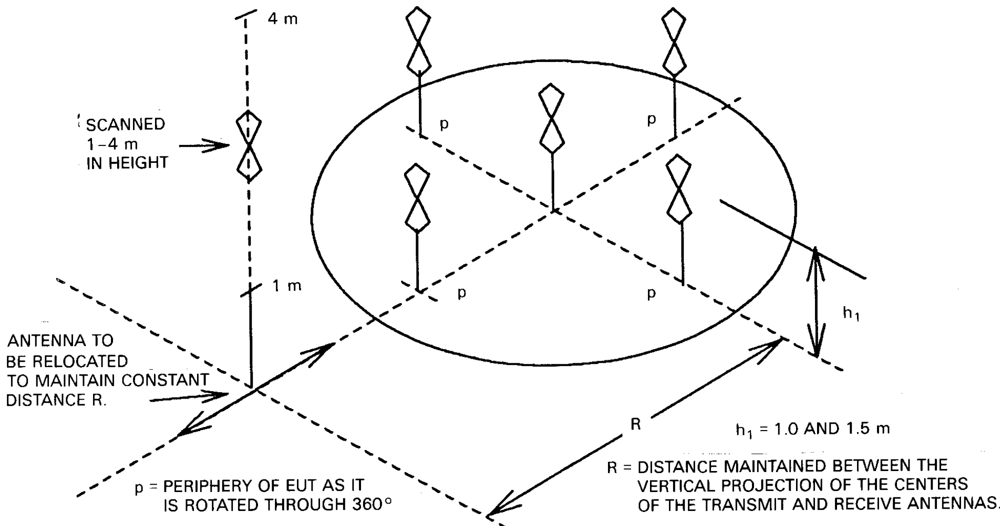


Fig 8(a)— Typical Antenna Positions for Alternate Test Site Vertical Polarization NSA Measurements

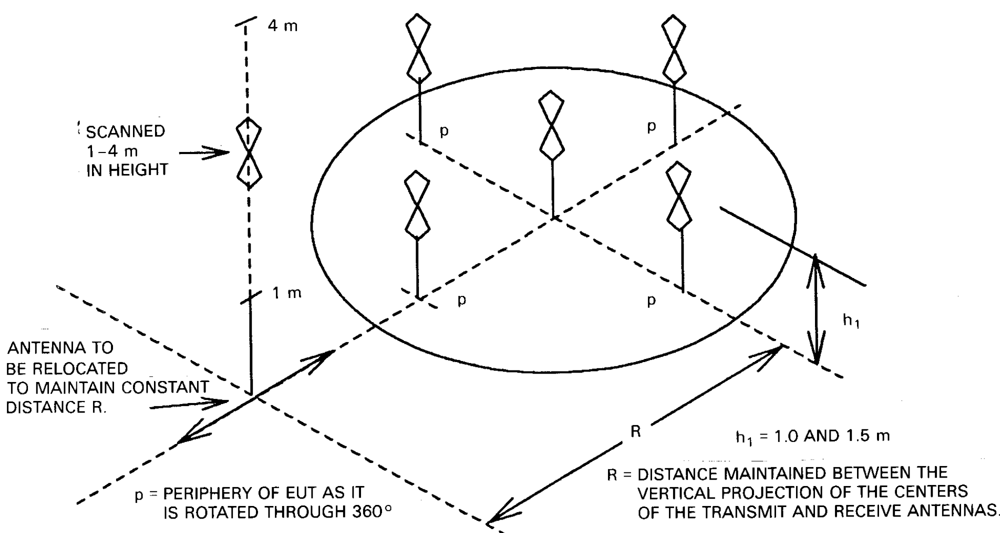


Fig 8(b)— Typical Antenna Positions for Alternate Test Site Horizontal Polarization NSA Measurements

The number of required measurements can be reduced under the following circumstances:

1) The vertical and horizontal polarization measurements in the rear position may be omitted if the closest point of the construction and/or absorbing material is at a distance of greater than 1 m from the rear boundary of the test volume (see NOTE 1 below).
2) The total number of horizontal polarization measurements along the test volume diameter joining the left and right positions may be reduced to the minimum number necessary for the antenna footprints to cover 90% of that diameter.
3) The vertical polarization measurements at the 1.5 m height may be omitted if the top of the EUT including any table mounting is less than 1.5 m in height.
4) If the test volume is no larger than 1 m in depth, by 1.5 m in width, by 1.5 m in height including table, if used, horizontal polarization measurements need be made at only the center, front, and rear positions but at both the 1 m and 2 m heights. If (1) above applies, the rear position may be omitted. This will require a minimum of eight measurements: four positions vertical polarization (left, center, right, and front) for one height, and four positions horizontal polarization (center and front) and for two heights; see Figs 8(c) and 8(d).

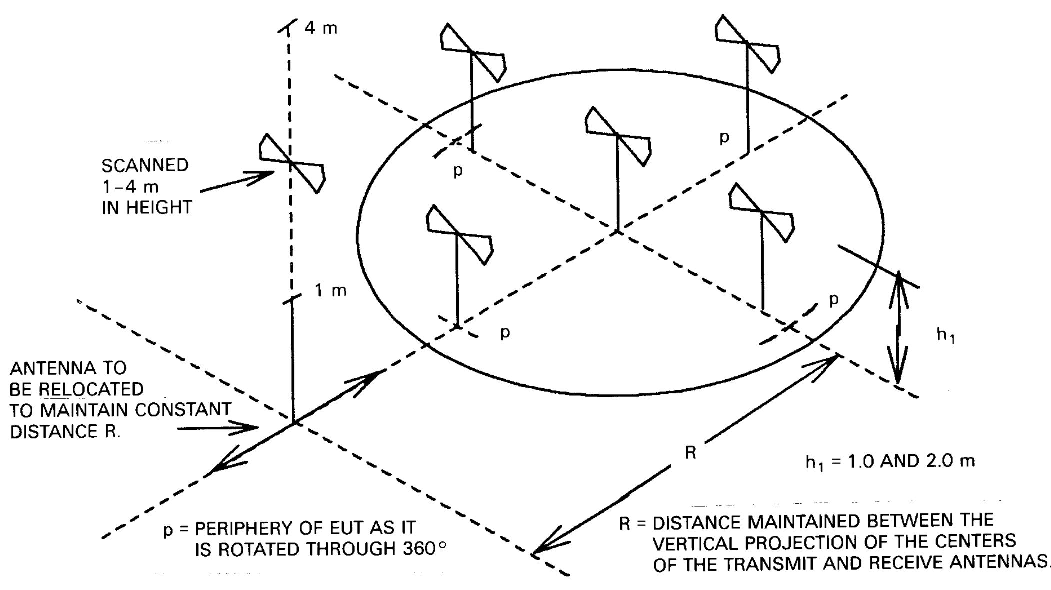


Fig 8(c)— Typical Antenna Positions for Alternate Test Site Vertical Polarization NSA Measurements for an EUT that Does Not Exceed a Volume of 1.0 m Depth, 1.5 m Width, 1.5 m Height, with the Periphery Greater than 1.0 m from the Closest Material that May Cause Undesirable Reflections

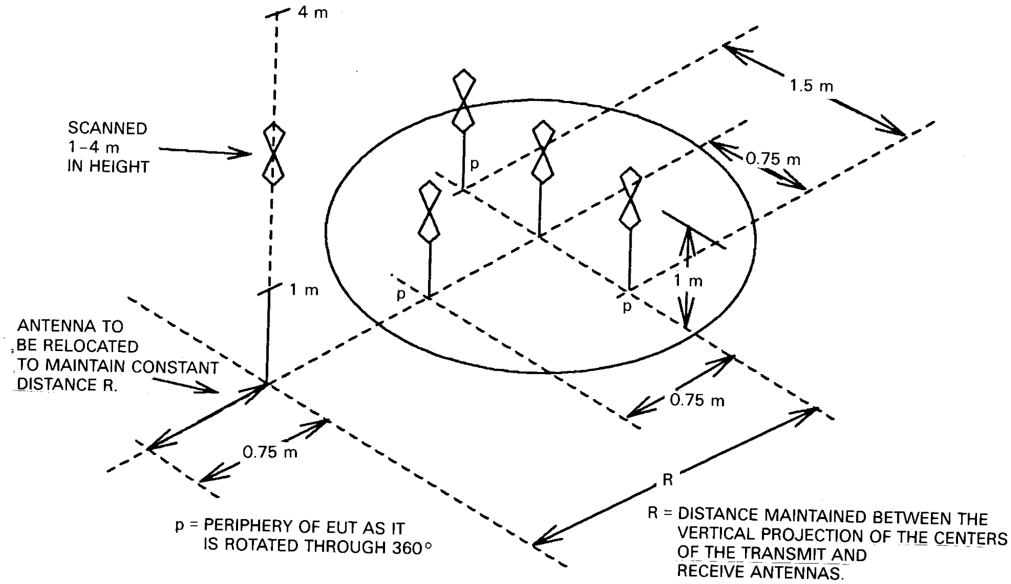


Fig 8(d)— Typical Antenna Positions for Alternate Test Site Horizontal Polarization NSA Measurements for an EUT that Does Not Exceed a Volume of 1.0 m Depth, 1.5 m Width, 1.5 m Height, with the Periphery Greater than 1.0 m from the Closest Material that May Cause Undesirable Reflections

NSA measurements shall be performed with the transmit and receive antenna separation held constant according to Tables 1, 2, and 3. The receive antenna must be moved along a line towards the turntable center to maintain the appropriate separation; see Figs 8(a), (b), (c) and (d). The alternative test site is considered suitable for performing radiated emissions testing if all NSA measurements prescribed above meet the requirements of 5.4.6.1 and the ground plane requirements of 5.4.3 (see NOTE 2).

NOTES:

1 — Radiated emissions sources located near dielectric interfaces such as absorbing pyramids or ferrite tiles have been shown to have variations in current distribution that can affect the radiation properties of the source at that location [B14]. When the EUT can be located near these interfaces, additional site attenuation measurements are required.

2 — Studies are underway to determine if any further tests are required to show alternate test site suitability.

5.5 Radiated Emissions Test Site Requirements Above 1 GHz

There are currently no test site validation requirements above 1 GHz. If a radiation test site meets site radiation requirements between 30 MHz and 1 GHz, it may be used for measurements above 1 GHz without additional site qualifications.

NOTE — Additional site validation requirements above 1 GHz are currently under study.

5.6 Testing at Manufacturers Location or Users Installation

Testing is permitted at the end user's or manufacturer's premises, if the equipment cannot be set up on an open area or alternate test site (see 8.3.2). In this case, both the equipment and its location are considered the EUT. The radiated emission test results are unique to the installation site because site containment properties affect the measurement. The ac powerline conducted emission test results also may be unique to the installation. However, where testing of a given system has been accomplished at three or more representative locations, the results may be considered representative of all sites with similar EUTs for purposes of determining compliance with emission requirements (if allowed in the procuring or requirements document). The voltage probe (see 4.1.3) shall be used for ac powerline conducted measurements. (See IEEE Std 139-1988 [11] for additional information).

Neither a conducting ground plane nor an LISN shall be installed for user's installation testing unless one or both are to be a permanent part of the installation.

5.7 Artificial Hand

If the EUT is normally operated while held in the hand, then when required by the procuring organization, measurements shall be made using an artificial hand to simulate the effects of the user's hand. If the EUT can be operated either held in the hand or not held, it shall be tested in both ways. The artificial hand shall consist of metal foil wrapped around the case, or part thereof, as specified below. The foil shall be connected to one terminal of a resistor-capacitor (RC) element consisting of a 200 pF capacitor in series with a 500 Ω resistor. The other terminal of the RC element shall be connected to ground. The EUT should be mounted 80 cm above the conducting ground plane for testing.

When the case of the EUT is entirely of metal, metal foil is not needed. The capacitor of the RC element shall be connected directly to the body of the EUT. When the case of the EUT is entirely of insulating material, metal foil shall be wrapped around the handle(s) and also wrapped around the body of the EUT that the user may contact. All pieces of metal foil shall be connected together and to the capacitor terminal of the RC element. When the case of the EUT is partly metal and partly insulating material, and has insulating handles, metal foil shall be wrapped around the handles and on the nonmetallic part of the body; the metal foils around the handles and the metal foil on the body shall be connected together and to the capacitor terminal of the RC element.

NOTE — An artificial hand shall not be used when testing ITE.

6. General Operating Conditions and Equipment Configurations

This section specifies general conditions that are applicable to all equipment covered under the scope of this document. Additional and more detailed requirements on specific types of EUTs are given in Sections 11 to 13.

6.1 Operating Conditions

The EUT and accessories shall be operated at the rated (nominal) operating voltage and typical load conditions—mechanical or electrical, or both—for which they are designed. Loads may be actual or simulated as described in the individual equipment requirements. For some EUTs, it may be necessary to develop a set of explicit requirements specifying the test conditions, EUT operations, etc., to be used in testing a specific EUT or class of EUTs for radio-noise emissions Such requirements shall be documented in the report of measurements for the EUT and may be used in determining compliance with the limits.

When used, the test programs or other means of exercising the equipment should ensure that the various parts of a system are exercised. For example, see 11.1 on ITE.

6.1.1 Equipment Under Test (EUT)

The EUT and accessories shall be placed in a typical configuration as defined in 6.2. They shall not be moved to maximize emissions unless specific instructions to do so are included in an individual test.

6.1.2 Accessory Equipment

Accessory equipment shall be placed in a typical configuration as defined in 6.2. Accessory equipment shall not be moved to maximize emissions unless specific instructions to do so are included in an individual test.

6.1.2.1 Remotely Located Devices

In certain applications, a remotely located device may be connected to the EUT. In these cases, it is permissible for cabling to the EUT or accessories to be placed directly upon the conducting ground plane or, if normally installed beneath the conducting ground plane, beneath it. The remotely located device shall be located at a distance sufficient to ensure that it does not contribute to the measured level. This test evaluates the interference potential of the EUT, its accessories, and interconnecting cables or wires standing apart from the remotely located device which, in turn, shall be evaluated separately.

Distributed networks, e.g., a local area network, may be simulated on the test site by a length of cable and an actual peripheral or a remote network communications simulator located at a distance sufficient to ensure that it does not contribute to the measured level. Signals impressed on the network by the EUT should be typical of normal operation.

6.1.3 EUT Ports (or Terminals)

Interconnect cabling or wiring shall be connected to one of each type of functional port of the EUT, and each cable or wire shall be terminated in a device typical of actual usage. Where there are multiple ports all of the same type, additional connecting cables or wires shall be added to the EUT to determine the effect these cables or wires have on emissions from the EUT. The number of additional cables or wires should be limited to the condition where the addition of another cable or wire does not significantly affect the emission level, i.e., varies less than 2 dB, provided, of course, that the emission level remains compliant. These additional cables or wires need not be terminated.

Normally, the loading of similar connectors, terminals, or ports is limited by the following:

1) Availability of multiple loads (for large systems)
2) Reasonableness of multiple loads representing a typical installation

The rationale for the selection of the configuration and loading of ports shall be included in the test report. Additional ports on support or interfacing units or simulators, other than those associated with the EUT or the minimum system required by 1.1.2 for ITE, need not be cabled or used during testing.

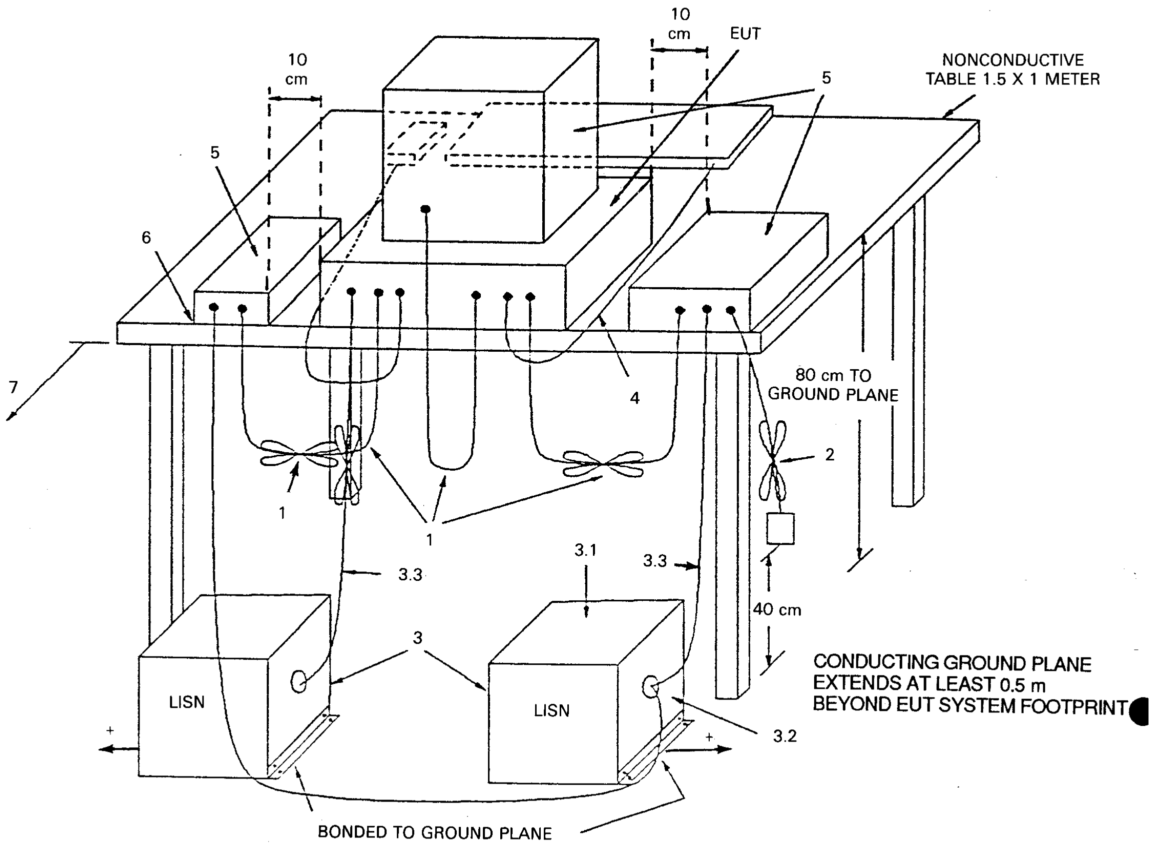
6.1.4 Interconnect Cabling (or Wiring)

The interconnecting cable length should be typical of normal usage. The interconnect cabling used during testing shall be the specific cabling marketed with the EUT in practical applications. Where cables of variable length are used with the EUT, the cables most typical of all applications shall be used throughout the testing. When cable length is unknown, cables of 1 m nominal length shall be used. The same type of cable (i.e., unshielded, braided, foil shield, etc.) specified in the user manual should be used throughout the tests.

For equipment tested on a tabletop, excess cable length will be draped over the back edge of the tabletop. If any draped cable extends closer than 40 cm to the conducting ground plane, the excess shall be bundled in the center in a serpentine fashion using 30 to 40 cm lengths to maintain the 40 cm height. If the cables cannot be bundled due to bulk, length, or stiffness, they shall be draped over the back edge of the tabletop unbundled, but in such a way that all portions of the interface cable remain at least 40 cm from the horizontal conducting ground plane, as shown in Figs 9(a) and 9(c).

Power cords of equipment other than the EUT do not require bundling. Drape the power cords of non-EUT equipment over the rear edge of the table and route them down onto the floor of the conducted test site to the second LISN. These power cords of non-EUT equipment should not be draped over the top of an LISN. See Figs 9(a) and 9(c).

For floor-standing equipment, excess cable length shall be folded back and forth in the center to form a bundle between 30 and 40 cm in length. If the cables cannot be folded due to bulk, stiffness, or length, they shall be arranged in a serpentine fashion [see Figs 9(b) and 9(d)].

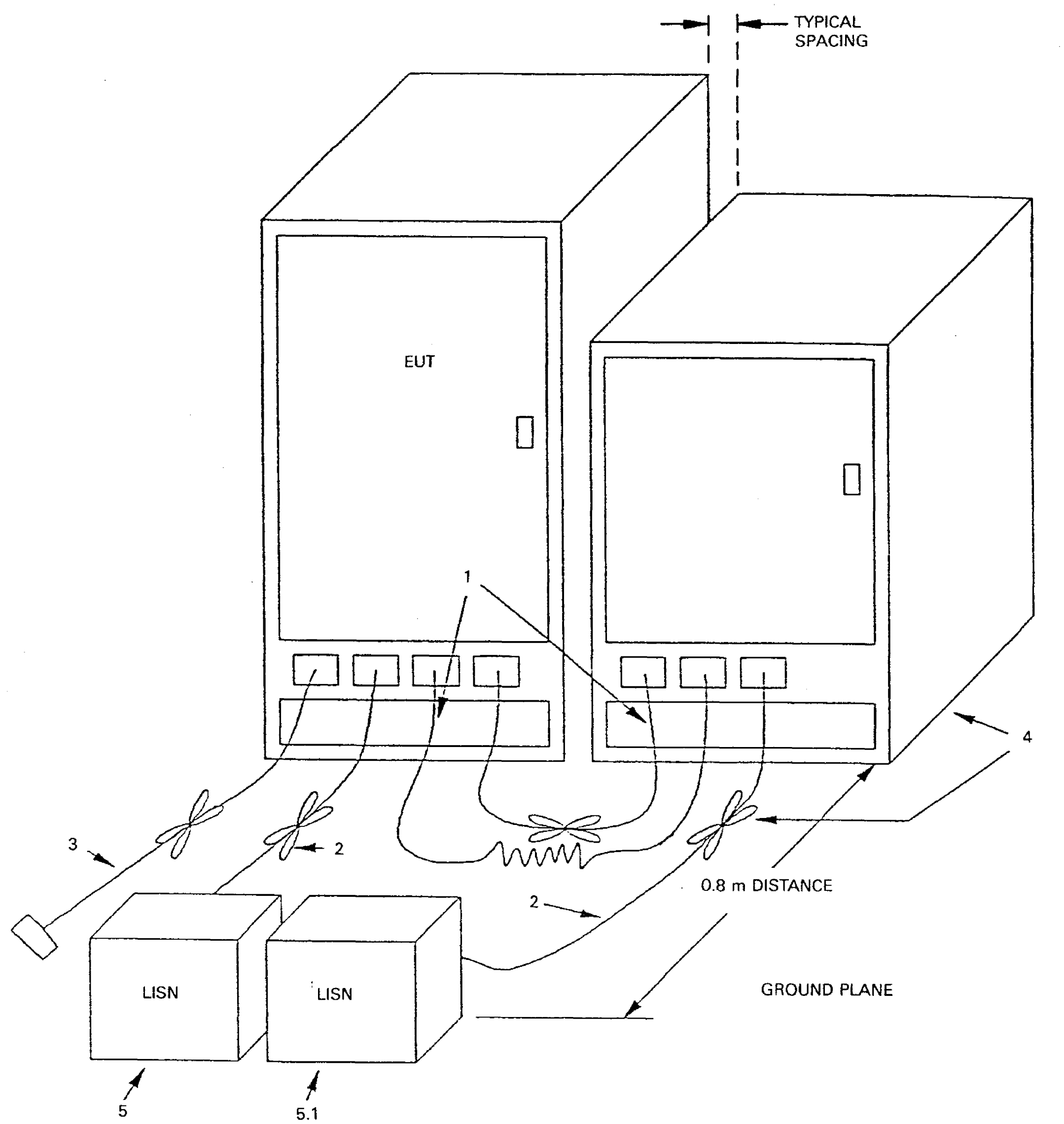


†LISNs may have to be moved to the side to meet 3.3 below.

LEGEND:

1. Interconnecting cables that hang closer than 40 cm to the ground plane shall be folded back and forth forming a bundle 30 to 40 cm long, hanging approximately in the middle between ground plane and table.
2. I/O cables that are connected to a peripheral shall be bundled in center. The end of the cable may be terminated if required using correct terminating impedance. The total length shall not exceed 1 m.
3. EUT connected to one LISN. Unused LISN connectors shall be terminated in 50 Ω. LISN can be placed on top of, or immediately beneath, ground plane.
   3.1 All other equipment powered from second LISN.
   3.2 Multiple outlet strip can be used for multiple power cords of non-EUT equipment.
   3.3 LISN at least 80 cm from nearest part of EUT chassis.
4. Cables of hand-operated devices, such as keyboards, mouses, etc., have to be placed as close as possible to the host.
5. Non-EUT components being tested.
6. Rear of EUT, including peripherals, shall be all aligned and flush with rear of tabletop.
7. Rear of tabletop shall be 40 cm removed from a vertical conducting plane that is bonded to the floor ground plane (see 5.2).

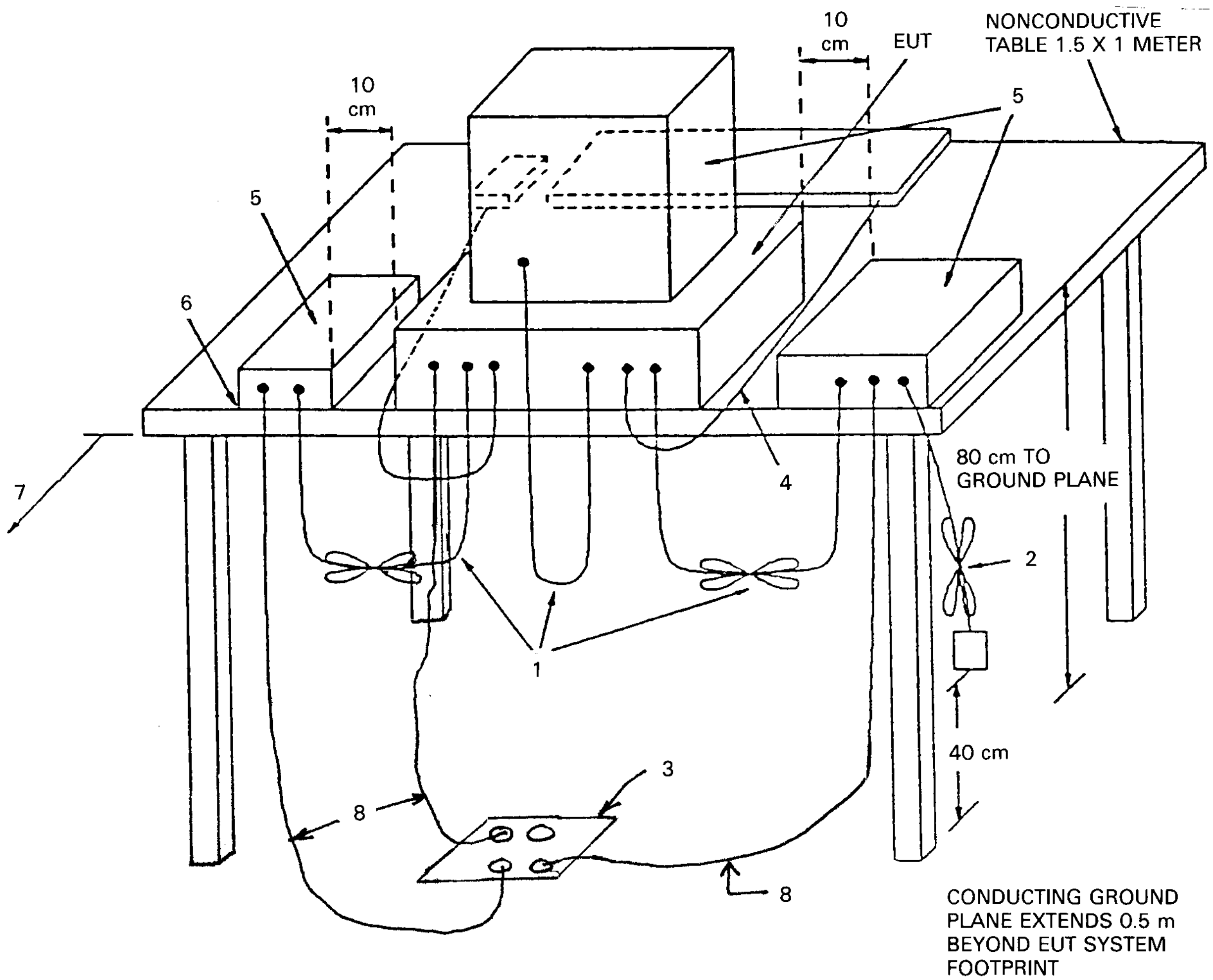
Fig 9(a)— Test Configuration Tabletop Equipment Conducted Emissions



LEGEND:

1. Excess I/O cables shall be bundled in center. If bundling is not possible, the cables shall be arranged in serpentine fashion. Bundling shall not exceed 40 cm in length.
2. Excess power cords shall be bundled in the center or shortened to appropriate length.
3. I/O cables that are not connected to a peripheral shall be bundled in the center. The end of the cable may be terminated if required using correct terminating impedance. If bundling is not possible, the cable shall be arranged in serpentine fashion.
4. EUT and all cables shall be insulated from ground plane by 3 to 12 mm of insulating material.
5. EUT connected to one LISN. LISN can be placed on top of, or immediately beneath, ground plane.
   5.1 All other equipment powered from second LISN.

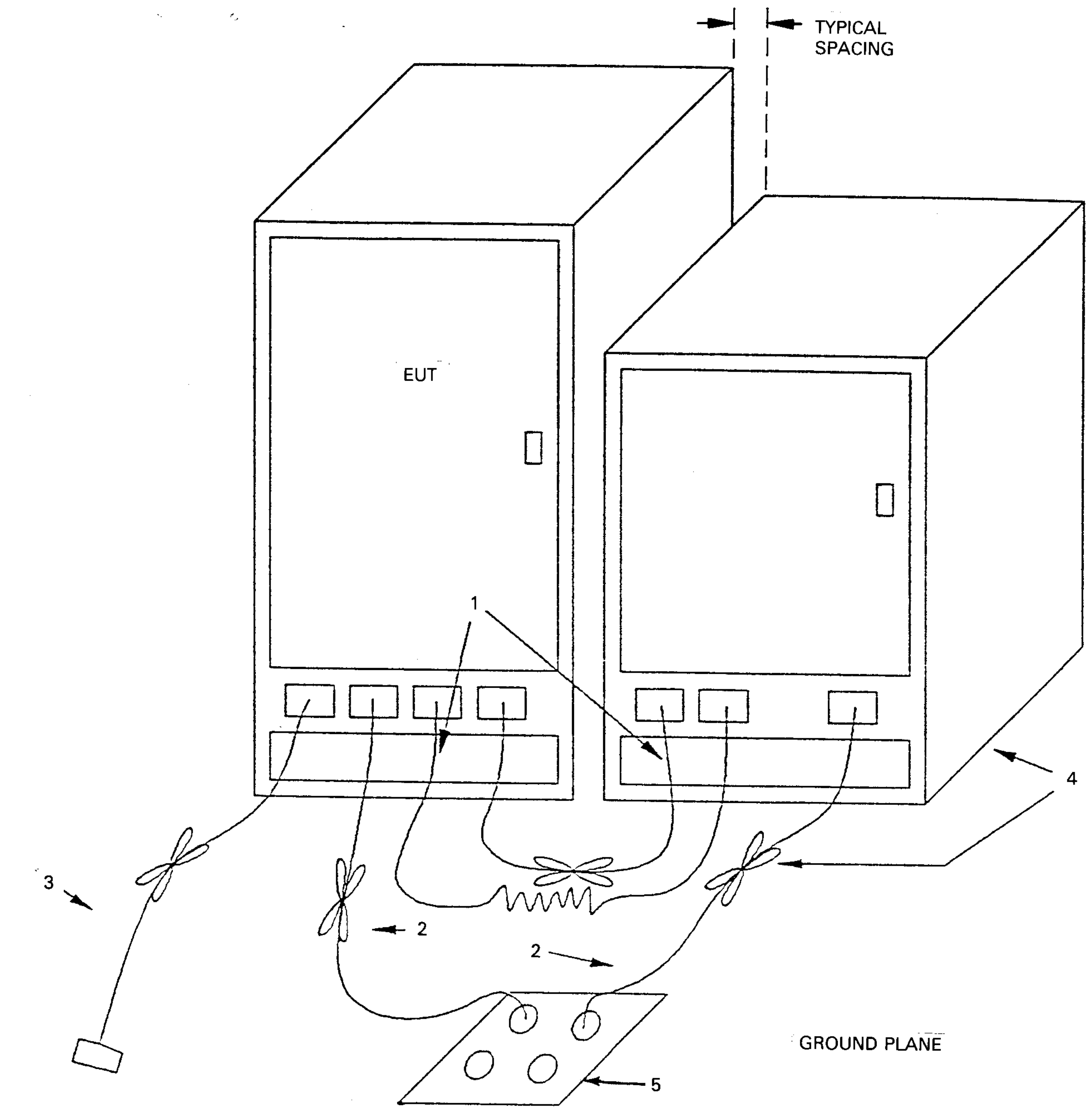
Fig 9(b)— Test Configuration Floor-Standing Equipment Conducted Emissions



LEGEND:

1. Interconnecting cables that hang closer than 40 cm to the ground plane shall be folded back and forth forming a bundle 30 to 40 cm long, hanging approximately in the middle between ground plane and table.
2. I/O cables that are connected to a peripheral shall be bundled in center. The end of the cable may be terminated if required using correct terminating impedance. The total length shall not exceed 1 m.
3. If LISNs are kept in the test setup for radiated emissions, it is preferred that they be installed under the ground plane with the receptacle flush with the ground plane.
4. Cables of hand-operated devices, such as keyboards, mouses, etc., have to be placed as close as possible to the controller.
5. Non-EUT components of EUT system being tested.
6. The rear of all components of the system under test shall be located flush with the rear of the table.
7. No vertical conducting wall used.
8. Power cords drape to the floor and are routed over to receptacle.

**Fig 9(c)— Test Configuration
Tabletop Equipment Radiated Emissions**



LEGEND:

1. Excess I/O cables shall be bundled in center. If bundling is not possible, the cables shall be arranged in serpentine fashion.
2. Excess power cords shall be bundled in the center or shortened to appropriate length.
3. I/O cables that are not connected to a peripheral shall be bundled in the center. The end of the cable may be terminated if required using correct terminating impedance. If bundling is not possible, the cable shall be arranged in serpentine fashion.
4. EUT and all cables shall be insulated from ground plane by 3 to 12 mm of insulating material.
5. If LISNs are kept in the test setup for radiated emissions, it is preferred that they be installed under the ground plane with the receptacle flush with the ground plane.

Fig 9(d)— Test Configuration
Floor-Standing Equipment Radiated Emissions

6.1.4.1 Overhead Cable Trays and Suspended Ceilings

Where overhead cable trays or suspended ceilings are used to support overhead cables, tests may be performed with overhead cable trays or suspended ceilings as shown in Fig 10. The trays or ceilings should be representative of a typical installation. Care is needed to precisely define the cable layout to be able to repeat the emission measurements.

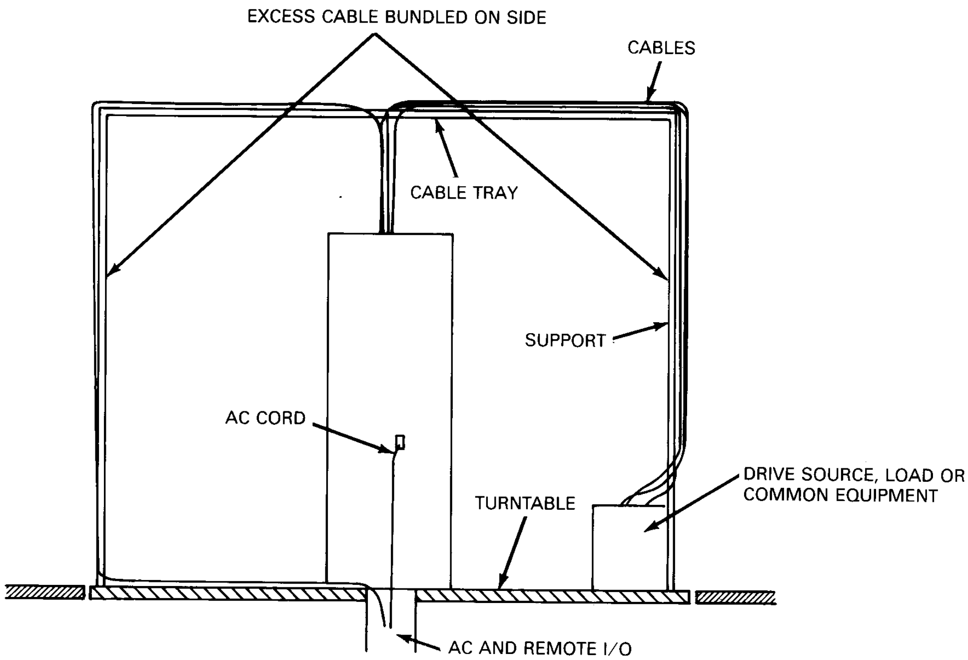


Fig 10— Test Configuration for Floor-Standing Equipment (Overhead Cables)

6.1.5 Modular Equipment

Equipment that is comprised of a unit populated with multiple plug-in printed circuit boards, modules, enhancement cards, co-processors, etc., shall be tested with a mix of plug-ins representative of that used in a typical installation. For installations with a large number of plug-ins, a representative number of plug-ins should be used. The exact rationale for selecting the number of plug-ins to use should be stated in the test report. A description of any process used to limit the number of modules to be tested should also be described in the test report. The number of additional plug-ins actually used should be limited to the number for which the addition of another plug-in does not significantly affect the emission level, i.e., varies less than 2 dB, provided, of course, that the emission level remains compliant. If applicable, each added plug-in shall have an interconnect cable or wire connected to it. These additional cables need not be terminated unless those boards are used in configuring a minimum system such as defined in 11.2.

6.1.6 Grounding

The EUT shall be grounded in accordance with the individual equipment requirements and conditions of intended use. When the EUT is furnished with a grounding-terminal or internally grounded lead, and when this terminal or lead is used in actual installation conditions, the terminal or lead shall be connected to the conducting ground plane or under the floor in a raised floor installation, simulating actual installation conditions. Any internally grounded lead included in the plug end of the line cord of the EUT shall be connected to ground through the utility power service (see also 7.2).

6.1.7 Simulators

In case the EUT is required to interact functionally with other units, the actual interfacing units shall be used to provide representative operating conditions unless there is some justified reason for using a simulator. If a simulator is used, the reasons for its use must be documented. For communication networks simulation, see 6.1.2.1.

6.1.8 Shock and Vibration Isolators

The EUT shall be secured to mounting bases having shock or vibration isolators, if such mounting bases are used in the normal installation. Any bonding straps furnished with the mounting base shall be connected to the conducting ground plane. When mounting bases do not have bonding straps, bonding straps shall not be used in the test arrangement.

6.1.9 Temperature and Humidity

The ambient temperature of the actual EUT shall be within the range of 10° to 40°C (50° to 104°F) unless the particular equipment requirements specify testing over a different temperature range. The EUT and the measuring equipment shall be operated for a sufficient period of time to approximate normal operating conditions and maintain the calibration of the measuring equipment unless specific test instructions preclude this. The warm-up time shall be included along with the measurement results if the ambient conditions are outside of the range stated above, and evidence shall be given that the measuring equipment is accurate at the temperatures used.

Humidity levels shall be in the range of 10% to 90% relative humidity unless the EUT operating requirements call for a different level. Unless specifically called out in the EUT requirements, there should be no condensation of moisture on the EUT. The ambient temperature and humidity levels should be recorded and included in the test report if critical to the test results.

6.1.10 Special Instrumentation

During the time radio-noise measurements are being made, external electrical meters or electrical indicating devices shall not be in the input or output circuits of the EUT, except those normally used with the measuring equipment.

6.2 Arrangement of EUT

The EUT shall be carefully configured, installed, arranged, and operated in a manner that is most representative of the equipment as typically used (i.e., as specified in the EUT instruction manual) or as specified herein. Equipment that typically operates within a system made up of multiple interconnected units should be tested as part of such a typical operational system.

Generally, the system that is tested is based on that typically marketed to the end user. If the marketing information is not available or it is not practical to assemble extraordinary amounts of equipment to replicate a complete marketed product installation, the test shall be performed using the best judgment of the test engineer in consultation with the design engineering staff. The results of any such discussion and decision process shall be reported in the test report.

In order to replicate emission measurements, it is important to carefully arrange, not only the system components, but also system cables, wires, and ac power cords. There are three general equipment test configurations: tabletop, floor-standing, and combination defined for testing all classes of devices as described below.

6.2.1 Tabletop Equipment Tests

Portable, small, lightweight or modular devices that may be hand-held, worn on the body, or placed on a table during operation shall be positioned on a nonconducting platform, the top of which is 80 cm above the ground plane. Ceiling and wall-mounted devices shall also be positioned on a tabletop for testing purposes. The preferred size of the tabletop platform is 1 m by 1.5 m, but it may be enlarged, if necessary, to allow for large systems. [See Figs 9(a), 9(c), and 11.]

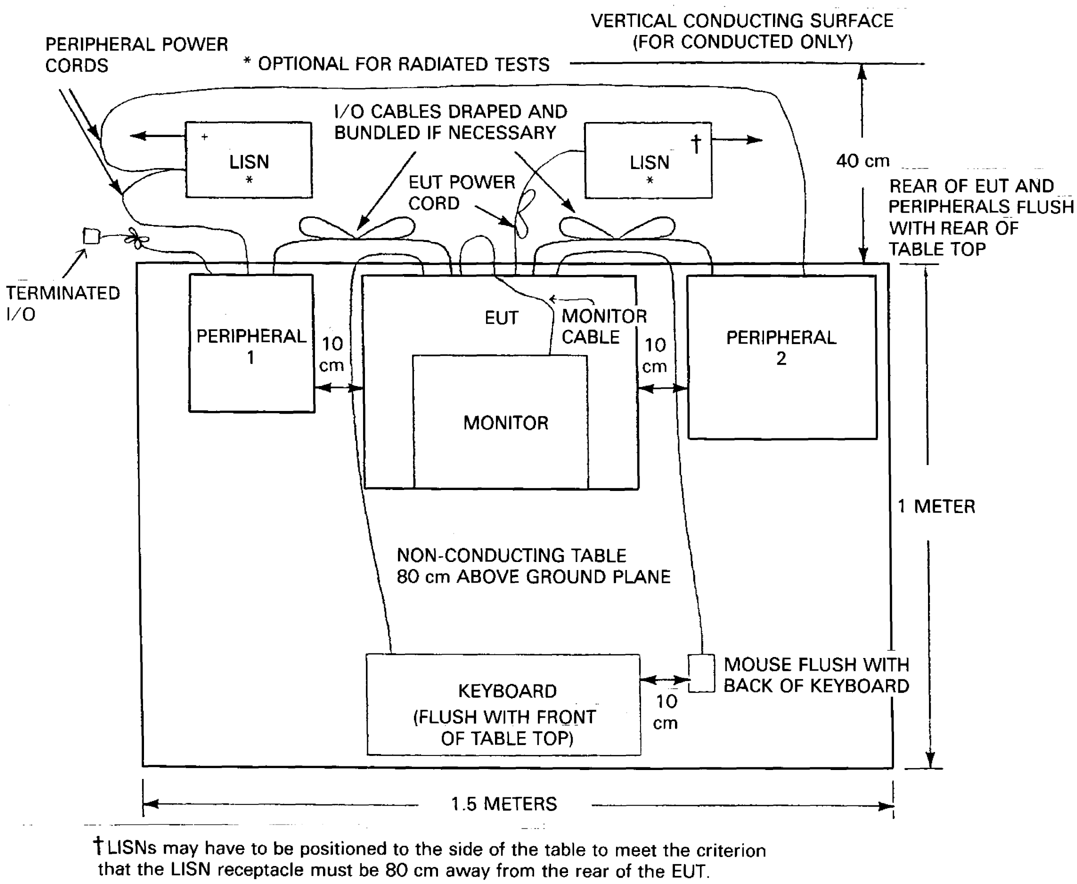


Fig 11— Test Configuration for Tabletop Equipment (Top View)

6.2.1.1 Placement of Tabletop EUTs

For tabletop systems, the EUT shall be centered laterally on the tabletop and its rear shall be flush with the rear of the table. If the EUT is a stand-alone unit, it shall be placed in the center of the tabletop.

6.2.1.2 Placement of Tabletop Accessories

Accessories that are part of a system tested on a tabletop shall be placed in a typical configuration with one accessory on either side of the EUT with a 10 cm separation (see Fig Fig 11—). If more than two accessories are present, a typical configuration should be chosen that maintains 10 cm spacing between cabinets unless the equipment is normally located closer together.

6.2.1.3 Placement and Manipulation of Interconnect Cabling (or Wiring) of Tabletop Equipment

The system shall be arranged in one typical equipment configuration for the test. In making any tests involving several tabletop equipments interconnected by cables or wires, it is essential to recognize that the measured levels may be critically dependent upon the exact placement of the cables or wires. Thus preliminary tests as specified in 7.2.3 and 8.3.1.1 should be carried out while varying cable positions in order to determine the maximum or near-maximum emission level. During manipulation, cables shall not be placed under or on top of the system test components unless such placement is required by the inherent equipment design.

6.2.2 Floor-Standing Equipment Tests

Large, heavy equipment, normally operated while placed on the conducting floor, shall be placed on the ground plane. If the equipment is normally placed on a nonconducting floor, it shall be separated from the conducting ground plane by 3 mm to 12 mm of electrical insulating material simulating the thickness of floor-covering material. [See Figs 9(b), 9(d), 10, and 12.]

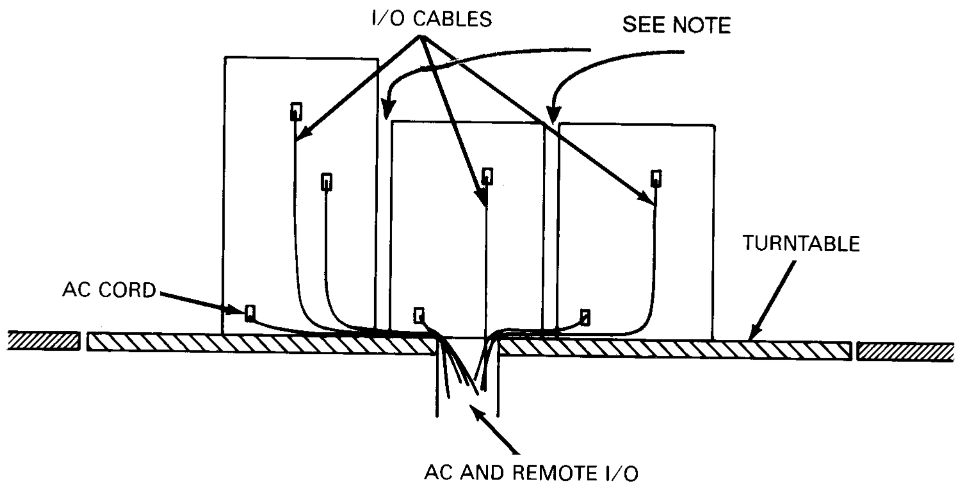


Fig 12— Test Configuration for Floor-Standing Equipment (Cables at or Below Floor Level)

Systems specially designed to be mounted over raised flooring that facilitates intrasystem connection are considered floor-standing systems for the purpose of testing. Such equipment can be interconnected with cabling lying on the floor, under the floor in a raised floor installation, or overhead according to normal installation.

6.2.2.1 Placement of Floor-Standing EUTs

Typical configurations for floor-standing equipment are shown in Figs Fig 10— and Fig 12—. Normally, tests shall be run with the devices standing on the conducting ground plane, with or without an insulating surface, as appropriate.

6.2.2.2 Placement of Floor-Standing Accessories

Accessories that are part of a floor-standing system shall be placed in one typical configuration with normal spacing between equipment cabinets or enclosures (see Figs 9(b), 9(d), 10, and 12). If more than two accessories are present, a typical configuration should be chosen that maintains normal spacing between all equipment cabinets or enclosures.

6.2.2.3 Placement and Manipulation of Interconnect Cabling (or Wiring) of Floor-Standing Equipment

Cables are not normally manipulated for floor-standing equipment where the typical installation is known. Instead, the cables shall be laid out as shown in Figs 9(b) and 9(d). If the configuration of a typical installation is not known or changes with each installation, cables of floor-standing equipment shall be manipulated to the extent possible to produce the maximum level of emissions, within the range of typical installations.

6.2.3 Combination Equipment Tests

Equipment that can be used as either a tabletop or floor-standing device shall be tested only in a tabletop configuration, unless otherwise required by the appropriate authorities.

A device that is part of a system of both tabletop and floor-standing equipment may be tested in two separate configurations (i.e., as a tabletop system for the tabletop equipment and then as a floor-standing system for the floor-standing equipment) as described in 6.2.1 or 6.2.2, respectively. If desired, however, the combination of equipment can be placed on the test site at one time as shown in Fig 13.

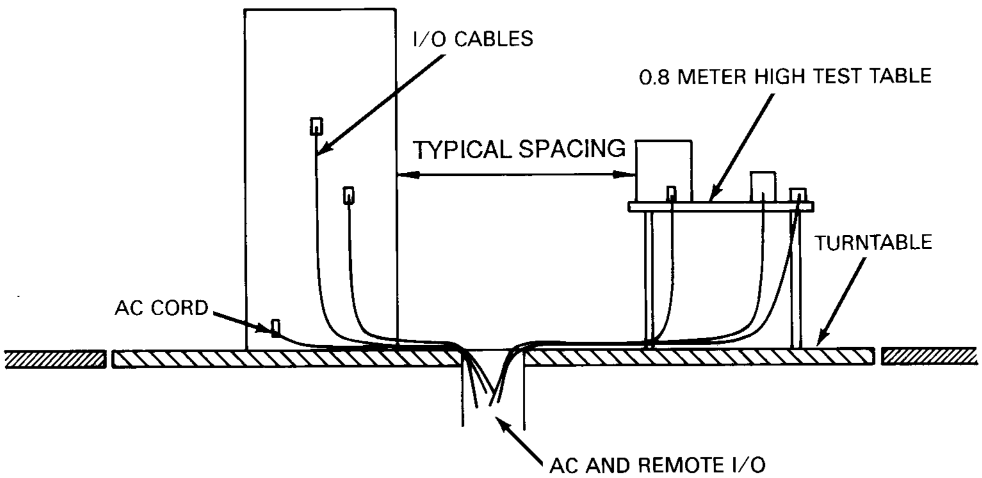


Fig 13— Test Configuration for Combination Floor-Standing and Tabletop Equipment (Cables at or Below Floor Level)

6.2.3.1 Placement of Combination Equipment EUTs

Tabletop or floor-standing EUTs shall be positioned following the guidelines in 6.2.1.1 or 6.2.2.1, respectively, unless this produces an atypical configuration. In such cases, position the EUT in a typical configuration for testing.

6.2.3.2 Placement of Combination Equipment Accessories

Tabletop or floor-standing accessories shall be positioned following the guidelines in 6.2.1.2 or 6.2.2.2, respectively, unless this produces an atypical configuration. In such cases, position the accessory or accessories in a typical configuration for testing.

6.2.3.3 Placement and Manipulation of Interconnect Cabling (or Wiring) of Combination Equipment

Follow the guidelines in 6.2.1.3 for placement and manipulation of cabling or wiring connecting two tabletop units or a tabletop unit and a floor-standing unit. Follow the guidelines in 6.2.2.3 for placement and manipulation of cabling connecting two floor-standing units.

7. AC Powerline Conducted Emissions Testing

Conducted powerline measurements shall be made, unless otherwise specified, over the frequency range from 450 kHz to 30 MHz to determine the line-to-ground radio-noise voltage that is conducted from the EUT power-input terminals that are directly (or indirectly via separate transformers or power supplies) connected to a public power network. These measurements may also be required between 9 kHz and 450 kHz.

If the EUT normally receives power from another device that connects to the public utility ac powerlines, measurements shall be made on that device with the EUT in operation to ensure that the device continues to comply with the appropriate limits while providing the EUT with power. If the EUT is operated only from internal or dedicated batteries, with no provisions for connection to the public utility ac powerlines (600 Vac or less) to operate the EUT (such as an adapter), ac powerline conducted measurements are not required.

7.1 Measurement Requirements

Measured levels of powerline conducted radio noise shall be the radio-noise voltage from the line probe or across the 50 Ω LISN port (to which the EUT is connected) or where permitted, terminated into a 50 Ω noise meter, or where permitted or required, the radio-noise current on the powerline sensed by a current probe. All radio-noise voltage and current measurements shall be made on each current-carrying conductor at the plug end of the EUT power cord or calibrated extension by the use of mating plugs and receptacles on the EUT and LISN if used. Equipment shall be tested with power cords that are normally used or that have electrical and shielding characteristics that are the same as those cords normally used. For those measurements using an LISN, the 50 Ω measuring port is terminated by a 50 Ω noise meter or a 50 Ω resistor load. Hence all 50 Ω measuring ports of the LISN are terminated by 50 Ω.

7.2 Test Procedures

7.2.1 Measurements at a Test Site

Tabletop devices shall be placed on a platform of nominal size, 1 m by 1.5 m, raised 80 cm above the conducting ground plane. The vertical conducting surface (see 5.2.2) or wall of a screened room shall be located 40 cm to the rear of the EUT. Floor-standing devices shall be placed either directly on the conducting ground plane or on insulating material as described in 6.2.2. All other surfaces of tabletop or floor-standing EUTs shall be at least 80 cm from any other grounded conducting surface including the case or cases of one or more LISNs.

Each EUT current-carrying power lead, except the ground (safety) lead, shall be individually connected through an LISN to the input power source. All unused 50 connectors of the LISN shall be resistively terminated in 50 Ω when not connected to the measuring instrument. When the test configuration comprises multiple units that have their own individual power cords, ac powerline conducted emissions measurements shall be performed with the line cord of the particular unit under test connected to one LISN that is connected to the measuring instrument. Those power cords for the units in the remainder of the configuration not under measurement may be connected to a multiple outlet, which in turn shall be connected to an LISN different from the LISN used for the power cord of the EUT. Typical ac powerline conducted emissions test setups are shown in Figs 9(a), 9(b), and 11. Each current-carrying conductor of the EUT shall be individually tested. Adapters connected between the EUT power cord plug and the LISN power socket shall be less than 20 cm long and contain only one plug and one outlet, or shall be included in the LISN setup such that the calibration of the combined adapter or extension cord with an adapter and the LISN meets the requirements of 5.2.3.

If the EUT is normally operated with a ground (safety) connection, the EUT shall be connected to the ground at the LISN through a conductor provided in the lead from the ac power mains to the LISN.

The excess length of the lead between the EUT and the LISN receptacle (or mains outlet where an LISN cannot be used), or an extension cord connected to and calibrated with the LISN, shall be folded back and forth at the center of the lead so as to form a bundle not exceeding 40 cm in length. If the EUT does not have a flexible power lead, it shall be placed at a distance of 80 cm from the LISN (or mains outlet where an LISN cannot be used) and connected thereto by a lead or appropriate connection no more than 1 m long. The measurement shall be made at the LISN end of this lead or connection.

The LISN housing, noise meter case, conducting ground plane, vertical conducting surface (see 5.2.2), etc., shall be bonded together.

7.2.2 On-Site AC Powerline Conducted Emissions Tests

If tests are performed at user's installations, the EUT shall be installed as normally used (see 5.6).

7.2.3 Preliminary AC Powerline Conducted Emissions Tests

Preliminary testing shall identify the frequency of the emission that has the highest amplitude relative to the limit by operating the EUT in selected typical modes of operation, typical cable positions, and with a typical or representative system configuration. For each mode of operation and for each current-carrying conductor, cable or wire manipulation shall be performed within the range of likely configurations. For this test or series of tests, the frequency spectrum of interest shall be monitored looking for the emission that has the highest amplitude relative to the limit. Once that emission is found for each current-carrying conductor of each power cord associated with the EUT, the one configuration and mode of operation that produces the emission closest to the limit is recorded.

7.2.4 Final AC Powerline Conducted Emissions Measurements

Based on the preliminary tests of the EUT, the one EUT and cable or wire configuration and mode of operation that produced the emission with the highest amplitude relative to the limit is selected for the final test. If the EUT is relocated from a preliminary test site to a final test site, the highest emissions shall be remaximized at the final test location before final ac powerline conducted emissions measurements are performed. The final test on all current-carrying conductors of the power cords that comprise the EUT is then performed without variation of the EUT configuration, cable or wire positions, or EUT mode of operation. Data shall be collected that satisfies the report requirements in Section 10.

8. Radiated Emissions Testing

Radiated emissions measurements shall be made over the frequency range specified by the procuring authority or regulatory agency or in a specific referenced document, but not outside of the frequency range of 9 kHz to 40 GHz.

8.1 Measurement Requirements

Measurements shall be made at the EUT azimuth and antenna height such that the maximum radiated emissions level will be detected. Ordinarily, this requires the use of a turntable as described in 5.4.4 and an antenna positioner.

Where a continuous azimuth search cannot be made, frequency scans of the EUT field strength with both polarities of the measuring antenna shall be made at a minimum of 16 azimuth angles around the EUT, nominally spaced by 22.5°, in characterizing the EUT radio-noise profile. If directional radiation patterns are suspected, additional azimuth angles shall be examined.

Figures 9(c) and 9(d) show typical test setups. Figures 10, 12, and 13 show variations of test setups for floor-standing or combinations of tabletop and floor-standing EUTs. The LISN, installed for the ac powerline conducted radio-noise measurement, may be left in the configuration for the radiated radio-noise tests, but unused terminals shall be terminated in 50 Ω. If the LISN is used as part of the test setup when making radiated emissions measurements, the receptacle for the EUT power connection to the LISN shall be bonded to the open area test site conducting ground plane and located flush with the conducting ground plane elevation. The LISNs shall be located such that they do not interfere with the radiated measurement accuracy. It is preferred theft they be located beneath the conducting ground plane.

8.2 Antenna Selection and Location

8.2.1 Magnetic Field Radiated Emissions

In the frequency range of 9 kHz to 30 MHz, magnetic field measurements may be performed. This method is applicable for radiated radio noise from all units, cables, power cords, and interconnect cabling or wiring. A calibrated loop antenna as specified in 4.1.5.1 shall be positioned with its plane vertical at the specified distance from the EUT and rotated about its vertical axis for maximum response at each azimuth about the EUT. For certain applications, the loop antenna may also need to be positioned horizontally at the specified distance from the EUT. The center of the loop shall be 1 m above the ground.

8.2.2 Electric Field Radiated Emissions Below 30 MHz

Electric field measurements may be made in the frequency range of 9 kHz to 30 MHz. This method is applicable for radiated radio noise from all units, cables, powerlines, and interconnecting wiring. A calibrated monopole (rod) antenna as specified in 4.1.5.2 shall be positioned at the specified distance from the EUT. The base of the monopole assembly should be placed on the conducting ground plane; and if the antenna is supplied with a counterpoise, the counterpoise shall be bonded to the conducting ground plane through a low-impedance connection.

8.2.3 Electric Field Radiated Emissions, 30 MHz to 1 GHz

Electric field measurements may be made in the frequency range of 30 MHz to 1000 MHz. A calibrated, linearly polarized antenna as specified in 4.1.5.3 shall be positioned at the specified distance from the periphery of the EUT.

NOTE — The specified distance is the horizontal separation between the closest periphery of the EUT and the center of the axis of the elements of the receiving antenna. However, if the receiving antenna is a log-periodic array, the specified distance shall be the distance between the closest periphery of the EUT and the front-to-back center of the array of elements.

Tests shall be made with the antenna positioned in both the horizontal and vertical planes of polarization. The measurement antenna shall be varied in height above the conducting ground plane to obtain the maximum signal strength. Unless otherwise specified, the measurement distance shall be 3 m, 10 m, or 30 m. At any measurement distance, the antenna height shall be varied from 1 m to 4 m.

These height scans apply for both horizontal and vertical polarization, except that for vertical polarization the minimum height of the center of the antenna shall be increased so that the lowest point of the bottom of the antenna clears the site ground surface by at least 25 cm. For a tuned dipole, the minimum heights as measured from the center of the antenna are shown in Table 3, columns 2, 4, and 6.

NOTE — Reference [B12] indicates significant differences in the vertically polarized data measured using broadband and tuned dipole antennas at minimum heights.

8.2.4 Electric Field Radiated Emissions, 1 GHz to 40 GHz

Radiated emissions measurements above 1 GHz are made using calibrated linearly polarized antennas as specified in 4.1.5.4, which may have a smaller beamwidth (major pattern lobe) than the antennas used for frequencies below 1 GHz. Since some EUTs may be larger than the beamwidth of the antenna at the specified separation distance, and since the source of emissions is generally limited to relatively small-angle cones of radiation, the antenna beamwidth shall be known so that when large EUTs are tested, the area of coverage of the EUT can be determined. Moving the measurement antenna over the surfaces of the four sides of the EUT or another method of scanning of the EUT is required when the EUT is larger than the beamwidth of the measuring antenna. When radiated measurements are made at the limit distance and the measurement antenna does not completely encompass a large EUT at that distance, additional measurements at a greater distance may be necessary to demonstrate that emissions were maximum at the limit distance.

For any EUT, the frequencies of emission should first be detected. Then the amplitudes of the emissions are measured at the specified measurement distance using the required antenna height, polarization, and detector characteristics.

It is preferred that measurements be performed on an open area test site or in an absorber-lined room. However, measurements may also be performed where there is adequate clearance, considering the radiation pattern of the EUT, to assure that any reflections from any other objects in the vicinity do not affect the measurements. Since the receiving antenna is unlikely to sense simultaneously both a direct signal and a signal reflected from the conducting ground plane, a conducting ground plane is not required, but may be used for measurements over 1 GHz.

In performing these measurements, the sensitivity of the measurement equipment relative to the limit shall be determined before the test. If the overall measurement sensitivity is inadequate, low-noise preamplifiers, closer measurement distances, higher gain antennas, or narrower bandwidths may be used. If closer measurement distances or higher gain antennas are used, the beamwidth versus size of the EUT shall be taken into account. Also, measurement system overload levels shall be determined to be adequate when preamplifiers are used. The effects of using bandwidths different from those specified shall also be determined. Any changes from the specific measurement conditions shall be described in the report of the measurements. (See also 10.1.4 and 10.1.9.)

Burn-out and saturation protection for the measuring instrumentation is required when low-level emissions are to be measured in the presence of a high-level signal. A combination of bandpass, bandstop, lowpass, and highpass filters may be used. However, the insertion loss of these or any other devices at the frequencies of measurement shall be known and included in any calculations in the report of measurements.

8.3 Test Procedures

8.3.1 Measurements on a Test Site

8.3.1.1 Preliminary Radiated Emissions Tests

Preliminary radiated measurements shall be performed at the measurement distance or at a closer distance than that specified for compliance to determine the emission characteristics of the EUT. At near distances, for EUTs of comparably small size, it is relatively easy to determine the spectrum signature of the EUT and, if applicable, the EUT configuration that produces the maximum level of emissions. A shielded room may be used for preliminary testing, but may have anomalies that can lead to significant errors in amplitude measurements.

Broadband antennas and a spectrum analyzer or a radio-noise meter with a panoramic display are often useful in this type of testing. It is recommended that either a headset or loudspeaker be connected as an aid in detecting ambient signals and finding frequencies of significant emission from the EUT when the preliminary and final testing is performed in an open area with strong ambient signals.

The EUT should be set up in its typical configuration and operated in its various modes. For tabletop systems, cables or wires should be manipulated within the range of likely configurations. For floor-standing equipment, the cables or wires should be located in the same manner as the user would install them and no further manipulation is made. If the manner of cable installation is not known, or if it changes with each installation, cables or wires for floor-standing equipment shall be manipulated to the extent possible to produce the maximum level of emissions.

For each mode of operation required to be tested, the frequency spectrum shall be monitored. Variations in antenna height, antenna polarization, EUT azimuth, and cable or wire placement (each variable within bounds specified elsewhere) shall be explored to produce the emission that has the highest amplitude relative to the limit. A step-by-step technique for determining this emission can be found in Appendix D.

When measuring emissions above 1 GHz, the frequencies of maximum emission shall be determined by manually positioning the antenna close to the EUT and by moving the antenna over all sides of the EUT while observing a spectral display. It will be advantageous to have prior knowledge of the frequencies of emissions above 1 GHz. If the EUT is a device with dimensions approximately equal to that of the measurement antenna beamwidth, the measurement antenna shall be aligned with the EUT.

8.3.1.2 Final Radiated Emissions Tests

Based on the test results in 8.3.1.1, the one EUT configuration, cable or wire configuration, and mode of operation that produces the emission that has the highest amplitude relative to the limit is selected for the final test. The final test is then performed on a site meeting the requirements of 5.3, 5.4, or 5.5 as appropriate without variation of the EUT configuration or EUT mode of operation. If the EUT is relocated from a preliminary test site to a final test site, the highest emission shall be remaximized at the final test location before final radiated emissions measurements are performed. However, antenna height and polarity and EUT azimuth are to be varied, and data shall be collected that satisfies the report requirements in Section 10.

For measurements above 1 GHz, use the one cable or wire and EUT configuration and mode of operation determined in the preliminary testing to produce the emission that has the highest amplitude relative to the limit. Move the measurement antenna away from each area of the EUT determined to be a source of emissions to the specified measurement distance while keeping the antenna in the “cone of radiation” from that area and pointed at the area both in azimuth and elevation, with polarization oriented for maximum response. The antenna may have to be higher or lower than the EUT, depending on the EUT's size and mounting height, but the antenna should be restricted to a range of heights of from 1 m to 4 m above the ground or ground plane. If the transmission line for the measurement antenna restricts its range of height and polarization, the steps needed to assure the correct measurement of the maximum emissions shall be described in detail in the report of measurements.

NOTES:

1 — Where limits are specified by agencies for both average and peak (or quasi-peak) detection, if the peak (or quasi-peak) measured value complies with the average limit, it is unnecessary to perform an average measurement.

2 — Use of waveguide and flexible waveguide may be necessary at frequencies above 10 GHz to achieve usable signal-to-noise ratios at required measurement distances. If so, it may be necessary to restrict the height search of the antenna, and special care should be taken to assure that maximum emissions are correctly measured.

3 — All presently known devices causing emissions above 10 GHz are physically small compared to the beamwidths of typical horn antennas used for EMC measurements. For such EUTs and frequencies, it may be preferable to vary the height and polarization of the EUT instead of the receiving antenna to maximize the measured emissions.

8.3.2 On-Site Measurements

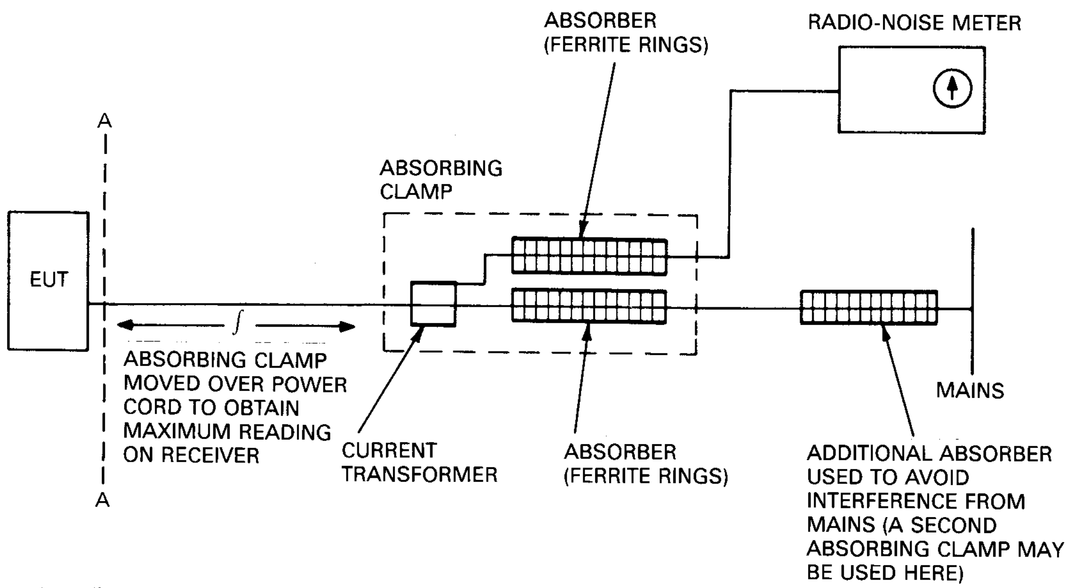
When it is required to make radiated emissions tests on site at a user's installation, the instructions in the product standards or applicable regulations shall be followed. Unless otherwise specified in the individual equipment requirements, measurements shall be made in accordance with 8.1 to locate the radial of maximum emission at the limit distance from the nearest point of the equipment being tested with antenna search heights as normally required. Where measurements at the limit distance from the EUT are impractical, measurements may be made at greater or lesser distances as near to the limit distance as practical and extrapolated to the limit distance (see 10.1.8.2). An LISN shall not be used for testing at the user's installation, unless the LISN is a part of the normal installation, in order that the measured radio noise be representative of the specific site. In the tests, the height of the antenna and its polarization are to be varied in accordance with the requirements of this section. For further guidance see IEEE Std 139-1988 [11].

9. Radio-Noise Power

Measurements of radio-noise power may be made in lieu of radio-noise radiated emissions measurements for certain restricted frequency ranges and for certain types of EUT. Such measurements utilize the calibrated absorbing clamp. Use of the clamp as an alternative to radiated emissions measurement shall be specified in the individual equipment requirements.

9.1 Absorbing Clamp Measurement Procedures

The test configuration for the measurement of radio-noise power is shown in Fig Fig 14—. The power cord connects the EUT with the commercial power source.



NOTE: AA DESIGNATES THE LOCATION OF A VERTICAL CONDUCTING SURFACE OR SCREENED-ROOM WALL USED FOR CALIBRATION PURPOSES; SEE G2.

Fig 14— Test Configuration for Radio-Noise Power Measurement

The EUT is placed on a nonmetallic table, or on the floor if it is a floor-standing unit, and is located at least 40 cm from any other metallic objects. The power cord is positioned to form a straight line so that the absorbing clamp can be moved along the power cord to determine the maximum radio noise. If radio-noise power is to be measured on a floor-standing unit, the power cord shall leave the EUT at an angle of less than 45° with respect to a horizontal plane, until it reaches a height 40 cm above the floor, then continue horizontally.

The absorbing clamp is then moved along the power cord and shall be positioned to absorb maximum power, that is, give the highest indication on the receiver. Normally, the maximum that is nearer to the EUT is used.

The radio-noise meter reading in dB(μV) is directly translatable to dB(pW) for the optimum coupling. The coupling varies from the optimum with distance from the EUT (first or second maximum) and frequency. The meter reading shall be corrected in accordance with the calibration data for the particular clamp used (see 4.4.3).

10. Test Reports

Test reports are the means of presenting the test results to the appropriate procuring or regulatory agency or for archiving the data in the permanent files of the testing organization. As such, test reports shall be clearly written, in unambiguous language.

10.1 Test Report Content

The conditions of test listed in the following sections shall be described in the test report in order for the test results to be properly documented.

10.1.1 Applicable Standards

In addition to this standard, any standards to which the EUT was tested shall be clearly described in the test report. Where referenced standards have more than one measurement procedure, or where the referenced measurement procedure has options, the test report shall state which procedures or options were used (see 1.2). The test report shall also state the issue or year of the referenced standard(s) used.

10.1.2 Equipment Units Tested

The test report shall list all equipment tested, including product type and marketing designations where applicable. Serial numbers and any other distinguishing identification features shall also be included in the test report. Identification or detailed description shall also be made of interconnecting cables.

The rationale for selecting the EUT (comprised of the equipment units needed to be functionally complete and the necessary cabling) shall be noted in the test report.

10.1.3 Equipment and Cable Configuration

The setups of the equipment and cable or wire placement on the test site that produce the highest radiated and the highest ac powerline conducted emissions shall be clearly shown and described. Drawings or photographs may be used for this purpose (see 10.1.12). A block diagram showing the interconnection of the major functional units is also useful.

10.1.4 List of Test Equipment

A complete list of all test equipment used shall be included with the test report. Manufacturer's model and serial numbers, and date of last calibration and calibration interval, shall be included. Measurement cable loss, measuring instrument bandwidth and detector function, video bandwidth, if appropriate, and antenna factors shall also be included where applicable.

10.1.5 Units of Measurement

Measurements of ac powerline conducted emissions, output, and spurious conducted emissions for TV interface devices, and antenna transfer switch isolation for TV interface devices shall be reported in units of dB referenced to one microvolt [dB(μV)]. Measurements of transfer switch isolation for cable TV switches shall be reported in units of dB below the input level. Measurements of electric field radiated emissions shall be reported in units of dB referenced to 1 microvolt per meter [dB(μV/m)] for electric fields or 1 A/m [dB (A/m)] for magnetic fields, respectively, at the distance specified in the appropriate standards or requirements. Measurements of antenna-conducted power for receivers may be reported in units of dB referenced to one microvolt [dB(μV)] if the impedance of the measuring instrument is also reported. Otherwise, report antenna-conducted power in units of dB referenced to 1 milliwatt [dBm]. Measurements of operating frequency, operating frequency with variations in ambient temperature and input voltage, and occupied bandwidth of intentional radiators shall be reported in units of hertz or multiples thereof [e.g., kilohertz (kHz), megahertz (MHz)]. Measurements of input power to intentional radiators shall be reported in units of watts. All formulas of conversions and conversion factors, if used, shall be included in the measurement report.

10.1.6 Location of Test Site

The location of the test site shall be identified in the test report. Sites that have received recognition from various accreditation bodies shall use the same site address information as was included in their original application for recognition.

10.1.7 Measurement Procedures

The sequence of testing followed to determine the emissions included in the test report should be documented. For example, the sequence used during preliminary testing in accordance with 7.2.3 and 8.3.1.1 should be given in the test report, in sufficient detail to allow replication of the test results by procuring or regulatory agencies, or if required to perform further tests and ongoing compliance checks.

10.1.8 Reporting Measurement Data

The measurement results along with the appropriate limits for comparison shall be presented in tabular or graphical form. Alternatively, recorded charts or photographs of a spectrum analyzer display may be used if the information is clearly presented showing comparison to the limits and all data conversion is explained. The method of comparing spectrum analyzer output to the limits shall be included.

10.1.8.1 AC Powerline Conducted Emissions Data

The frequency and amplitude of the six highest ac powerline conducted emissions relative to the limit and the operating frequency or frequency to which the EUT is tuned (if appropriate) shall be reported unless such emissions are more than 20 dB below the limit. If less than six emissions are within 20 dB of the limit, the noise level of the measuring instrument at representative frequencies shah be reported. The specific conductor for each of the reported emissions shall be identified.

10.1.8.2 Radiated Emissions Data

For unintentional radiators other than ITE, for each of the frequencies to which the device is tuned, the frequency and amplitude of the six highest radiated emissions relative to the limit and the operating frequency or frequency to which the EUT is tuned (if appropriate) shall be reported unless such emissions are more than 20 dB below the limit. If less than the specified number of six emissions are within 20 dB of the limit, the noise level of the measuring instrument at representative frequencies shall be reported. For intentional radiators, for each of the frequencies to which the device is tuned, the frequency and amplitude of the highest fundamental emission, the frequency and amplitude of the three highest harmonic or spurious emissions relative to the limit, and the frequency and amplitude of the three highest restricted band emissions relative to the limit shall be reported. The polarization of the measurement antenna (horizontal or vertical) shall be identified for each of the reported emissions. Radiated emissions measurements taken at alternative distances are to be converted to the limit distance using the inverse distance relationship, unless data can be presented to validate a different conversion. At a particular frequency, the polarization with the highest level shall be reported.

10.1.8.3 Antenna-Conducted Power Data for Receivers

For each of the frequencies to which the receiver is tuned, if antenna-conducted power measurements are performed, the frequency to which the receiver is tuned, the frequency and level of the six highest emissions relative to the limit, and the impedance of the measuring instrument shall be reported unless such emissions are more than 10 dB below the limit. If less than six emissions are within 10 dB of the limit, the noise level of the measuring instrument at representative frequencies shall be reported.

10.1.8.4 Output and Spurious Conducted Data for TV Interface Devices

For each channel provided in the EUT, the output channel and the peak RF levels as follows shall be reported: (1) the visual carrier, (2) the aural carrier, (3) the three highest spurious emissions relative to the limit observed in the range from 30 MHz to 4.6 MHz below the visual carrier frequency, and (4) the three highest spurious emissions relative to the limit observed from 7.4 MHz above the visual carrier frequency to 1 GHz. If the spurious emissions observed are more than 20 dB below the limit, the noise level of the measuring instrument at representative frequencies shall be reported. The operating mode of the EUT and modulation for each data point shall also be listed.

10.1.8.5 Antenna Transfer Switch Data

For cable TV antenna transfer switches either internal or external to a device, the minimum isolation level above 216 MHz and the minimum isolation level below 216 MHz for each pair of antenna input ports or terminals shall be reported. For antenna transfer switches associated with TV interface devices, the peak RF level of the visual carrier measured at each antenna input port or terminal for every output channel provided in the EUT shall be reported. For both types of switches, the input port, modulating signal, device powered on or off, and switch position for each data point shall also be listed.

10.1.8.6 Operating Frequency Data for Intentional Radiators

On each operating frequency measured, if required on an intentional radiator, the frequency and the time after startup of each measurement shall be reported. The ambient temperature at which these measurements were made shall also be reported.

10.1.8.7 Frequency Stability Data for Intentional Radiators

For frequency stability versus ambient temperature measurements, if required on an intentional radiator, the chamber temperature, the operating frequency, the frequency deviation in percent from nominal rated channel frequency, and the time after startup of each measurement shall be reported for the number of operating frequencies required to be measured. For frequency stability versus input voltage, the ac or dc voltage supplied to the EUT, the operating frequency, the frequency deviation in percent from nominal rated channel frequency, and the chamber temperature shall be reported for each of the operating frequencies measured.

10.1.8.8 Occupied Bandwidth Data for Intentional Radiators

On each operating frequency measured, if occupied bandwidth measurements are required on an intentional radiator, the occupied bandwidth shall be reported. This may be accomplished by providing tabular data, photographs, or plots of the measuring instrument display. If photographs or plots of instrument display are submitted as data, the axes, the scale units per division, and the limit shall be clearly labeled.

10.1.8.9 Input Power Data for Intentional Radiators

On each operating frequency measured, if input power measurements are required on an intentional radiator, the input power to the device shall be reported.

10.1.9 General and Special Conditions

If an alternate test method was used, the test report shall identify and describe that method, provide justification for its use, and describe how the results obtained through its use correlate with the methods specified by the standard to which the EUT was tested. Instrumentation, instrument attenuator and bandwidth settings, detector function, EUT arrangement, and all other pertinent details of the test shall be provided so that the alternate test method could be replicated. Where automatic scan techniques were used, an explanation of how the highest emission relative to the limit from the EUT was determined and the scan rate used (see 4.1.1.1) to obtain recorded emissions is to be included in the test report. The actual operating and environmental conditions (e.g., voltage, powerline frequency, temperature, relative humidity, etc.) shall be listed in the report.

10.1.10 Summary of Results

The test report summary section shall indicate whether the EUT passes or fails, and give margins with respect to the limits to which it was tested. If the equipment only passes with specific modifications or special attributes (such as shielded cables), this information shall be included in the summary results.

10.1.11 Required Signatures

The test report shall contain the signature of the representative of the organization performing the tests. In addition, the test report shall contain the identification of the staff who were responsible for the proper execution of the test, and the name and address of the party requesting the tests. If changes are made during the period of test to bring the EUT into compliance, the test report shall so indicate. In addition, the report submitted to the procuring organization or regulatory agency shall include a signed statement by the manufacturer or developer agreeing to the changes and their incorporation into production.

10.1.12 Test Report Appendixes

The test report shall contain, if required, photographs or detailed sketches of the EUT configuration, showing sufficient information to allow the EUT to be reconfigured in a manner that would allow the original test to be replicated with a high likelihood that the test results would be in agreement with the results of the original test within acceptable tolerances.

10.2 Test Report Disposition

The test report shall be maintained by the testing organization for a period of at least three years following the date of the test. The manufacturer may be required by a regulatory agency to maintain a copy of the report for a longer period of time.

11. Measurement of Information Technology Equipment (ITE)

This section contains information applying specifically to ITE. In general, testing is performed as specified in Sections 6 through 8 with the additions, specific clarifications, and exceptions described in this section.

This section prescribes many required procedures and guidelines designed to enhance repeatability. If a particular EUT cannot be tested according to these rules, it is permissible to test the EUT in a manner dictated by good engineering judgment. Deviations from the prescribed procedure are permitted only where justified by typical usage but may require approval of the appropriate authority. Any deviations from the prescribed procedure shall be described and fully justified as outlined in 1.2 and 10.1.9.

Depending upon the internally generated frequency of the ITE (digital device), measurements may be specified on the average, CISPR quasi-peak or peak basis, or a combination of these detector functions. Because of the complexity of the individual equipment requirements, careful study of these requirements is recommended before proceeding with testing.

11.1 Operating Conditions

As pointed out in 6.1, all parts of the system shall be exercised. For example, in a computer system, tape and disk drives shall be put through a read-write-erase sequence, various portions of memories shall be addressed, any mechanical activities shall be performed, and video units shall display a variety of characters.

11.1.1 Hosts

The host, typically a CPU, should be tested as part of a system. If the host is a personal computer, it shall be tested with peripherals as described in 11.2. Interface cables shall be connected to one of each type of functional interface port on the host, and each cable should be terminated in a peripheral load typical of actual usage.

11.1.2 Peripherals

Any peripheral being tested separately shall be driven by the appropriate host equipment. The host for a personal computer peripheral shall be the personal computer typical of actual usage. If the host is a personal computer, the host and peripheral under test shall be tested with any additional equipment needed to satisfy the minimum system requirements of 11.2.

11.1.3 Visual Display Units

If the EUT system includes a visual display unit or monitor, the following operational conditions apply:

1) Set the contrast control to maximum.
2) Set the brightness control to maximum or at raster extinction if raster extinction occurs at less than maximum brightness.
3) For color monitors, use white letters on a black background to represent all colors.
4) Select the worse case of positive or negative video if both alternatives are available.
5) Set character size and number of characters per line so that the typical maximum number of characters per screen is displayed.
6) For a monitor that has no graphics capabilities, regardless of the video card used, a pattern consisting of random text shall be displayed. For a monitor with graphics capability, even though another video card may be needed to accomplish a graphic display, a pattern consisting of a line of scrolling H's should be displayed. For a monitor that has no text capabilities, use a typical display.

11.2 Tabletop Systems

Follow the general guidelines in 6.2.1 for placement of the EUT, placement of the peripherals, and placement and manipulation cf interface cables for testing tabletop ITE systems.

For a personal computer or a peripheral intended to be used with a personal computer, the minimum system consists of the following devices grouped and tested together:

1) Personal computer
2) Keyboard
3) Video display unit
4) An external peripheral for each of two different types of available I/O protocols, e.g., serial, parallel, etc.
5) If the EUT has a dedicated port for a special-purpose device, e.g., a mouse, joystick, or external disk drive, that device shall be part of the minimum system.

NOTE — Items (1), (2), and/or (3) may, in some systems, be assembled in the same chassis. In no instance may items (1), (2), or (3) or joystick controls, satisfy the requirements of item (4).

Figures 9(a) through 9(d) and 11 show the recommended equipment and cable configurations that are described in 6.2.1 and 11.2 through 11.2.4.

11.2.1 Placement of Host

For tabletop hosts, the host shall be centered laterally on the tabletop and its rear shall be flush with the rear of the table.

11.2.2 Placement of Monitors and Keyboards

The monitor should be placed on top of the host, centered and flush with the front of the host. The keyboard shall be positioned in front of the monitor, centered on the monitor, and flush with the front edge of the tabletop surface.

11.2.3 Placement of External Peripherals

External peripherals that are part of a tabletop system shall be placed in a single configuration to either side of the host with a 10 cm separation. If more than two external peripherals are present, a typical configuration should be chosen that maintains 10 cm spacing between all equipment cabinets. A mouse or joystick shall be positioned 10 cm to the right of the keyboard (see Fig 11).

11.2.4 Placement and Manipulation of Interface Cables

Excess interface cable length will be draped over the back edge of the tabletop for tabletop equipment. If any draped cable extends closer than 40 cm to the conducting ground plane, the excess shall be bundled in the center in a serpentine fashion using 30 to 40 cm lengths to maintain the 40 cm height. If the cables cannot be bundled due to bulk, length, or stiffness, they shall be draped over the back edge of the tabletop unbundled, but in such a way that all portions of the interface cable remain at least 40 cm from the horizontal conducting ground plane, as shown in Figs 9(a) and 9(c).

The system shall be arranged in one typical equipment configuration for the test. In making any tests involving several pieces of tabletop equipment interconnected by interface cables, it is essential to recognize that the measured levels may be critically dependent upon the exact placement of the interface cables. Thus preliminary tests as specified in 7.2.3 and 8.3.1.1 should be carried out while varying cable positions in order to determine the maximum or near-maximum emission level. During manipulation, cables shall not be placed under or on top of the system test components unless such placement is required by the inherent equipment design.

If the monitor can be powered through an outlet on the host unit, it shall be tested in two ways, i.e., powered through the host, and powered separately as required during preliminary ac powerline conducted and radiated emissions testing.

11.3 Floor-Standing Equipment Configurations

Follow the general guidelines in 6.2.2 for placement of the EUT, placement of peripherals, and placement and manipulation of interface cables for testing a floor-standing ITE system.

11.4 Combination Tabletop and Floor-Standing Equipment Configurations

Follow the general guidelines in 6.2.3 for placement of the EUT, placement of peripherals, and placement and manipulation of interface cables for testing a combination tabletop and floor-standing ITE system.

11.5 AC Powerline Conducted Emissions Tests

The following paragraphs describe the procedures that may be used for performing the final ac powerline conducted emissions tests of ITE. Additional guidance and step-by-step procedures for preparing the setups and carrying out the required ac powerline conducted and radiated tests for personal computers and associated peripherals are given in Appendix E.

11.5.1 Preliminary AC Powerline Conducted Emissions Tests

Using the procedure in 7.2.3, determine the mode of operation and cable positions of the EUT system that produce the emission with the highest amplitude relative to the limit. This configuration will be used in final ac powerline conducted emissions testing of the EUT.

11.5.2 Final AC Powerline Conducted Emissions Measurements

Using the mode of operation and configuration of the EUT determined in 11.5.1, follow the procedure in 7.2.4 to perform final ac powerline conducted emissions measurements. Record the six highest emissions relative to the limit of all the current-carrying conductors of the power cords that comprise the EUT over the frequency range specified by the procuring or regulatory agency. See 10.1.8.1 for reporting requirements. Photograph or diagram the test setup that was used (see 10.1.12).

The quasi-peak detector function, specified for use between 150 kHz and 30 MHz, may not indicate the same subjective interference level for both narrowband and broadband sources. This has been recognized and ways to account for the unequal interference potential of narrowband and broadband emissions have been adopted.

NOTE — For ITE in the United States, the frequency range for ac powerline conducted emissions measurements is 450 kHz to 30 MHz.

When the procuring organization or regulatory agency specifies two limits using different detector functions in the measuring instrument, ac powerline conducted emissions shall be measured with the specified detector functions and emissions shall comply with the appropriate limit.

When only one limit is specified requiring the quasi-peak detector function, and if the EUT exhibits ac powerline conducted emissions that exceed the limit with the instrument set to the quasi-peak mode, then measurements should also be made in the average mode. If the amplitude measured in the quasi-peak mode is at least 6 dB higher than the amplitude measured in the average mode, the level measured in the quasi-peak mode may be reduced by 13 dB before comparing it to the limit. If the 13 dB reduced quasi-peak mode level is below the limit, the EUT is considered to have met the limit requirements. When exercising this option, the following conditions shall be observed:

1) The measuring instruments with the quasi-peak and average detector shall have a linear response.
2) The quasi-peak and average measurement instrument shall have the same nominal bandwidth.
3) When measuring an emission with a low duty cycle, the dynamic range of the measuring instrument shall not be exceeded.

11.6 Radiated Emissions Tests

The following paragraphs describe the procedures that may be used for performing the final radiated emissions tests of ITE. Additional guidance and step-by-step procedures for preparing the setups and carrying out the required radiated emissions tests for personal computer and associated peripherals are given in Appendix E.

11.6.1 Preliminary Radiated Emissions Tests

Using the procedure in 8.3.1.1, determine the mode of operation and cable positions of the EUT system that produce the emission with the highest amplitude relative to the limit. This configuration will be used in final radiated emissions testing of the EUT.

11.6.2 Final Radiated Emissions Measurements

Using the mode of operation and configuration of the EUT determined in 11.6.1, follow the procedure in 8.3.1.2 to perform final radiated emissions measurements. Record the six highest emissions relative to the limit in the frequency range specified by the procuring or regulatory agency. See 10.1.8.2 for reporting requirements. Photograph or diagram the test setup that was used (see 10.1.12).

12. Measurement of Unintentional Radiators Other than ITE

This section contains information applying specifically to unintentional radiators other than ITE, such as receivers, VCRs, TV interface devices, and similar devices that are not intended to radiate RF energy. In general, testing is performed as specified in Sections 6 through 8. with the additions, specific clarifications, and exceptions described in this section.

This section prescribes many required procedures and guidelines designed to enhance repeatability. If a particular EUT cannot be tested according to these procedures, it is permissible to test the EUT in a manner dictated by good engineering judgment. Deviations from the prescribed procedure are permitted only where justified by typical usage and may require approval of the appropriate authority. Any deviations from the prescribed procedure shall be described and fully justified as outlined in 1.2 and 10.1.9.

Depending upon the unintentional radiator operating frequency range, measurements may be specified on the average, CISPR quasi-peak or peak basis, or a combination of these detector functions. Because of the complexity of the individual equipment requirements and different measurement requirements, careful study of the agency regulations is recommended before proceeding with actual testing.

12.1 Measurement of Receivers

This section contains information that applies only to the testing of receivers.

FM and TV broadcast receivers shall be measured for radiated emissions in accordance with the procedures set forth in IEEE Std 187-1990 [13] or EIA-378 [8]. AC powerline conducted emissions shall be measured in accordance with the procedures set forth in IEEE Std 213-1987 [14].

For nonbroadcast receivers, the test procedures in the following subsections should be followed.

12.1.1 Operating Conditions

Equipment that interacts with accessory devices (i.e., sends digital information to and/or receives digital information from accessory devices via interconnecting wires) shall be tested as part of a typical operational system. The selection and placement of cables, ac power cords, and system components depend on the type of EUT and must be representative of expected equipment installation.

Equipment that does not interact with accessory devices (e.g., only sends audio information to passive accessories, such as external speakers, or provides video information to auxiliary devices, such as VCRs, that are subject to their own regulatory requirements) shall be tested with only those accessories normally marketed with the particular equipment.

If the EUT is a nonbroadcast receiver that operates on more than one frequency or over a frequency range or ranges, unless otherwise specified, all measurements shall be made with the EUT set to the number of frequencies in each band as provided in the following table:

Frequency range over which device operates	Number of frequencies	Location in the range of operation
Less than 1 MHz	1	1 near middle
1 to 10 MHz	2	1 near top and 1 near bottom
More than 10 MHz	3	1 near top, 1 near middle, and 1 near bottom

Unless otherwise specified in the individual tests, a receiver shall be supplied with the signal described below to simulate normal operation.

12.1.1.1 Superregenerative Receiver

A signal generator, not the matching transmitter, shall be used to radiate an unmodulated continuous wave (CW) signal to a superregenerative receiver at its operating frequency in order to "cohere" or resolve the individual components of the characteristic broadband emissions from such a receiver. The level of the signal may need to be increased for this to occur.

If a superregenerative receiver is tested for radiated emissions with a resistive termination instead of an antenna connected to the antenna input terminals, apply the unmodulated signal at a level of approximately –60 dBm to the antenna terminals, using an impedance-matching network if necessary, to "cohere" the emissions. It may be necessary to adjust the signal level to accomplish this.

12.1.1.2 Other Types of Receivers

A typical signal or an unmodulated CW signal at the operating frequency of the EUT shall be supplied to the EUT for all tests. Such a signal may be supplied by either a signal generator and an antenna in close proximity to the EUT, or directly conducted into the antenna terminals of the EUT. The signal level shall be sufficient to stabilize the local oscillator of the EUT.

12.1.2 Equipment Configurations

Follow the general guidelines in 6.2 for placement of the EUT, placement of accessories, and placement and manipulation of interconnecting cables and wires for testing an individual receiver or system.

12.1.3 AC Powerline Conducted Emissions Tests

The following paragraphs describe the procedures that may be used for performing final ac powerline conducted emissions tests on receivers. Additional guidance and step-by-step procedures for preparing the setups and carrying out the required ac powerline conducted tests for receivers are contained in Appendix H.

12.1.3.1 Preliminary AC Powerline Conducted Emissions Tests

On any one convenient frequency specified in 12.1.1, use the procedure in 7.2.3, while applying the appropriate signal to the EUT, to determine the operating frequency and cable or wire positions of the EUT system that produce the emission with the highest amplitude relative to the limit. This configuration will be used in final ac powerline conducted emissions testing of the EUT.

12.1.3.2 Final AC Powerline Conducted Emissions Measurements

Using the operating frequency and configuration of the EUT determined in 12.1.3.1, follow the procedure in 7.2.4, while applying the appropriate signal to the EUT, to perform final ac powerline conducted emissions measurements.

Record the six highest EUT emissions relative to the limit of all the current-carrying conductors of the power cords that comprise the EUT over the frequency range specified by the procuring or regulatory agency. See 10.1.8.1 for reporting requirements. Diagram or photograph the test setup that was used (see 10.1.12).

12.1.4 Radiated Emissions Tests

Receivers may be tested for radiated emissions with a terminating resistor, rather than an antenna, connected to the antenna input ports or terminals, providing the receiver is also tested for antenna-conducted power as specified in 12.1.5.

The following paragraphs describe the procedures that may be used for performing final radiated emissions tests on receivers with either antennas or terminating resistors connected to the antenna input terminals. Additional guidance and step-by-step procedures for preparing the setups and carrying out the required radiated tests for receivers are contained in Appendix H.

12.1.4.1 Preliminary Radiated Emissions Tests

On the number of frequencies specified in 12.1.1, use the procedure in 8.3.1.1, while applying the appropriate signal to the EUT, to determine the operating frequency and cable or wire positions of the EUT system that produce the emission with the highest amplitude relative to the limit. The EUT antenna shall be manipulated through typical positions during preliminary testing to maximize emission levels. In addition, preliminary radiated emissions testing of handheld or body-worn devices shall include rotation of the EUT through three orthogonal axes to determine the attitude that maximizes the emissions. This configuration will be used in final radiated emissions testing of the EUT.

12.1.4.2 Final Radiated Emissions Measurements

Using the operating frequency, attitude, and configuration of the EUT determined in 12.1.4.1, follow the procedure in 8.3.1.2, while applying the appropriate signal to the EUT, to perform final radiated emissions measurements.

Record the six highest EUT emissions relative to the limit over the frequency range specified by the procuring or regulatory agency. See 10.1.8.2 for reporting requirements. Diagram or photograph the test setup that was used (see 10.1.12).

12.1.5 Antenna-Conducted Power Measurements

Antenna-conducted power measurements shall be performed when a receiver is measured for radiated emissions with a terminating resistor instead of an antenna connected to the antenna input terminals of the device. Power on the receive antenna terminals is to be determined by measurement of the voltage present at these terminals. For frequencies below or equal to 1000 MHz, a CISPR quasi-peak detector shall be used for these measurements. If the signals comply with the peak reading, then no further investigation of the quasi-peak readings is required. For frequencies above 1000 MHz, both a peak and average detector shall be used for these measurements. If the unit complies with the peak limits, then no further investigation of the average readings is required.

NOTE — Where agencies specify limits for both average and peak detection, if the peak measured value meets the average limit, it is unnecessary to perform an average measurement.

Antenna-conducted power measurements shall be performed with the EUT antenna terminals connected directly to either a spectrum analyzer or another measuring instrument (see 4.1.1), if the antenna impedance matches the impedance of the measuring instrument. Otherwise, use a balun or impedance-matching network to connect the measuring instrument to the antenna terminals of the EUT. Losses in decibels in any balun or impedance-matching network used shall be added to the measured value in dBμV.

With the receiver tuned to one of the number of frequencies specified in 12.1.1, measure both the frequency and voltage present at the antenna input terminals over the frequency range specified in the individual equipment requirements. Repeat this measurement with the receiver tuned to another frequency until the number of frequencies specified in 12.1.1 have been successively measured. Power on the receive antenna terminals is the ratio of V^2/R, where V is the loss-corrected voltage measured at the antenna terminals, and R is the impedance of the measuring instrument. See 10.1.8.3 for reporting requirements.

Additional guidance in step-by-step procedures for preparing, setting up, and carrying out the required measurements are contained in Appendix H5.

12.2 Measurement of TV Interface Devices

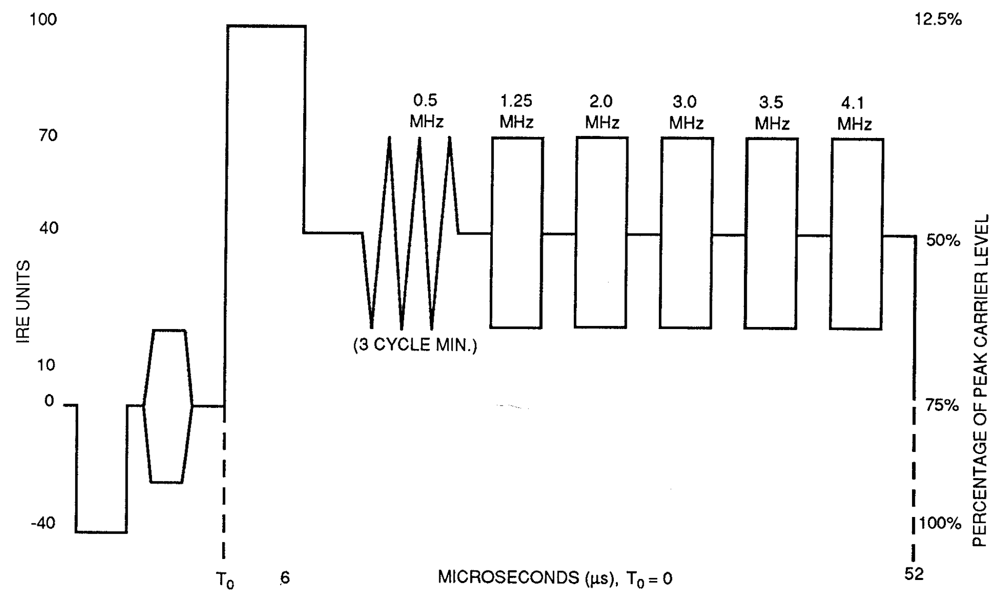
This section contains information that applies only to the testing of TV interface devices. A TV interface device may be a TV (video) game, a VCR, or a cable TV converter.

12.2.1 Operating Conditions

Unless otherwise specified in the individual tests, all input terminals or connectors on a TV interface device shall be terminated in the proper impedance. However, the output ports or connectors of these devices shall be connected to either (1) the cable provided with the device or (2) a cable of typical length. Unless otherwise specified in the individual tests, the output cable shall be connected to either a terminating resistor of the proper impedance or the antenna transfer switch provided with the device. All other antenna transfer switch ports shall be terminated in the proper impedance.

For TV interface devices equipped with multiple inputs, the signals described below shall be individually applied during preliminary tests to determine which input produces the highest emission relative to the limit.

NOTE — Unless specified in an individual test, a VCR shall be operated in the playback and record modes. In addition, the following record signals shall be investigated to determine which produces the highest emission relative to the limit: (1) a National Television Systems Committee (NTSC) TV signal supplied through the antenna input part, (2) a 1 V peak-to-peak vertical interval test signal (VITS) as shown in Fig Figu 15— supplied through the video input part, and (3) a 5 V peak-to-peak VITS signal supplied through the video input port.



Figu 15— Multiburst Test Signal (Full Field)

12.2.1.1 Internal Modulation Sources

For devices that contain an internal modulation source, e.g., TV games, that source shall be active during testing.

12.2.1.2 Video Modulation Sources

For devices that have a baseband video input, e.g., VCRs, a VITS shall be applied alternately with an amplitude of both 1 and 5 V peak to peak.

12.2.1.3 RF Modulation Sources

For devices that have antenna terminals for reception of over-the-air TV broadcast signals, e.g. VCRs, an NTSC TV signal shall be supplied. For devices that have a cable TV input, e.g., cable system terminal devices (CSTD), two cable TV input signal levels shall be supplied alternately, first, 0 dB(mV), and then 25 dB(mV).

12.2.1.4 Other External Modulation Sources

For devices that use external modulation sources other than that specified above, apply a typical signal.

12.2.2 Equipment Configurations

Follow the general guidelines in 6.2 for placement of the EUT, placement of accessories, and placement and manipulation of interconnecting cables and wires for testing an individual TV interface device or system.

An antenna transfer switch that is connected to the output cable of a TV interface device shall be manipulated with the output cable as if it were an interconnecting cable. The antenna transfer switch is not stationary like an accessory to the EUT.

12.2.3 AC Powerline Conducted Emissions Tests

The following paragraphs describe the procedures that may be used for performing final ac powerline conducted emissions tests on TV interface devices. Additional guidance and step-by-step procedures for preparing the setups and carrying out the required ac powerline conducted tests for TV interface devices are contained in Appendix H.

12.2.3.1 Preliminary AC Powerline Conducted Emissions Tests

On each output channel of the TV interface device, use the procedure in 7.2.3, while applying the appropriate signals to the EUT, to determine the output channel, operating mode, and cable or wire positions of the EUT system that produce the emission with the highest amplitude relative to the limit. This configuration will be used in final ac powerline conducted emissions testing of the EUT.

12.2.3.2 Final AC Powerline Conducted Emissions Measurements

Using the output channel, operating mode, and configuration of the EUT determined in 12.2.3.1, follow the procedure in 7.2.4, while applying the appropriate signals to the EUT, to perform final ac powerline conducted emissions measurements.

Record the six highest EUT emissions relative to the limit of all the current-carrying conductors of the power cords that comprise the EUT over the frequency range specified by the procuring or regulatory agency. Diagram or photograph the test setup that was used (see 10.1.12).

12.2.4 Radiated Emissions Tests

The following paragraphs describe the procedures that may be used for performing final radiated emissions tests on TV interface devices. Additional guidance and step-by-step procedures for preparing the setups and carrying out the required radiated emissions tests for TV interface devices are contained in Appendix H.

12.2.4.1 Preliminary Radiated Emissions Tests

On each output channel of the TV interface device, use the procedure in 8.3.1.1, while applying the appropriate signals to the EUT, to determine the output channel, operating mode, and cable or wire positions of the EUT system that produce the emission with the highest amplitude relative to the limit. This configuration will be used in final radiated emissions testing of the EUT.

12.2.4.2 Final Radiated Emissions Measurements

Using the output channel, operating mode, and configuration of the EUT determined in 12.2.4.1, follow the procedure in 8.3.1.2, while applying the appropriate signals to the EUT, to perform final radiated emissions measurements.

Record the six highest EUT emissions relative to the limit over the frequency range specified by the procuring or regulatory agency. See 10.1.8.2 for reporting requirements. Diagram or photograph the test setup that was used (see 10.1.12).

12.2.5 Output and Spurious Conducted Level Measurements

The output or spurious signal level is the maximum voltage level present at the output terminal(s) of a TV interface device (i.e., VCR, CSTD, or TV game) on a particular frequency during normal use of the device. The maximum voltage corresponds to the peak envelope power of a modulated signal during maximum amplitude peaks.

Measurements shall be made of the levels of the aural carrier, visual carrier, and all spurious emissions for each TV channel on which the device operates by following the procedure below.

Use the same configuration and test setup used for radiated measurements to measure the output signal level of the EUT. Connect the output cable of the EUT to the measuring instrument using the length of interconnecting cable (1) provided with the TV interface device, (2) recommended in the instruction manual, or (3) normally employed by the consumer. When the output cable is coaxial cable, measurements shall be made by direct connection to the measuring instrument with proper impedance matching between the measuring instrument and the EUT. If the output cable is 300 Ω transmission line (twinlead), measurements are to be made through an appropriate balun with connecting cables kept as short as practical. It may be necessary to connect a high-gain, low-noise amplifier between the EUT and the measuring instrument to increase the signal-to-noise ratio of the signals being measured.

Support the cable between the EUT and the measuring instrument in a straight horizontal line so it has at least 75 cm clearance from any conducting surface. Terminate all unused inputs and outputs on the EUT's antenna transfer switch with the proper impedance.

Set the bandwidth of the measuring instrument according to the frequency being measured as follows:

Measurement Frequency	Bandwidth
below 30 MHz	10 kHz
30 to 1000 MHz	100 kHz
above 1000 MHz	1 MHz

Turn on the EUT and allow a sufficient period of time for the unit to warm up to its normal operating condition. Provide the EUT with a typical signal consistent with normal operation. For each channel on which the device operates and in each mode in which the device operates, measure and record the level the video carrier, audio carrier, the three highest spurious emissions above the video carrier, and the three highest spurious emissions below the video carrier over the frequency range specified in the individual equipment requirements, the frequency of the emission and output channel of the EUT. See 10.1.8.4 for reporting requirements.

Additional guidance in step-by-step procedures for preparing, setting up, and carrying out the required measurements is contained in Appendix H6.

12.2.6 Antenna Transfer Switch Measurements for Unintentional Radiators

Measurements of antenna transfer switch isolation shall be made with the unintentional radiator configured for typical operation. Isolation shall be measured for all positions of a cable TV antenna transfer switch on the frequencies specified in the individual tests. Isolation shall be measured for all positions of an antenna transfer switch on all output channels of a TV interface device. All unused RF ports or terminals of the unintentional radiator or the antenna transfer switch shall be terminated with the proper impedance during these measurements.

12.2.6.1 Cable TV Antenna Transfer Switches

The following describes the procedure to be used to measure the isolation of a cable TV selector switch that is either built in to an unintentional radiator or is a stand-alone switch. The isolation of a cable TV antenna transfer switch shall be measured on the following frequencies: 54, 100, 150, 200, 250, 300, 350, 400, 450, 500, and 550 MHz using the procedure below. If the device or switch is equipped with more than two antenna input ports or terminals, repeat the following procedure until isolation for each pair of input ports has been measured.

NOTE — Only input ports on the device or switch intended for connection to an antenna are considered antenna input ports.

The cable TV antenna transfer switch isolation, expressed in decibels, is the difference between the level of a signal going into the port that is used for cable TV input to the switch and the level of the same signal coming out of an antenna input port of the transfer switch. Be sure to compare emission levels of the same frequency. The signal levels are expressed in decibel units.

Position the device containing the switch in accordance with 6.2.1 or 6.2.2. Place a stand-alone cable TV antenna transfer switch on a table 80 cm in height above the ground. Connect a signal generator to the port that is used for cable TV input with a suitable length of coaxial cable. Connect the port of the switch designated for antenna input to the measuring instrument with a suitable length of coaxial cable. Support both of these cables in a straight horizontal line so they have at least 75 cm clearance from any conducting surface. If necessary, impedance-matching devices shall be used and they shall be connected as close as possible to the port(s) on the antenna transfer switch. Terminate all other antenna input ports on the transfer switch in the proper impedance.

Turn on the device containing the cable TV switch, if appropriate. Adjust the output of the signal generator to provide a CW signal at a level of 0 dBm on one of the above frequencies. Tune the measuring instrument to the signal generator frequency. Set the detector function to the peak mode, and adjust the bandwidth and attenuator settings to any convenient position to obtain the highest level. Do not change the measuring instrument settings during the measurements on this frequency. Change the positions of the switch on the antenna transfer switch and record the level and frequency of the signal and the position of the switch that gives the highest indication on the measuring instrument. Turn the device off and repeat this measurement.

Without changing the settings on the measuring instrument, disconnect the antenna transfer switch from the test setup.

Connect the signal generator to the measuring instrument using the matching transformers and coaxial cables that were connected to the switch. Tune the frequency control on the measuring instrument to obtain the highest level, measure, and record the level of this signal. Record the difference between the level going directly into the measuring instrument and the level going through the antenna transfer switch. This is the cable TV antenna transfer switch isolation for that frequency.

Repeat this process at each frequency listed above. See 10.1.8.5 for reporting requirements.

Additional guidance in step-by-step procedures for preparing, setting up, and carrying out the required measurements is contained in Appendix H7.

12.2.6.2 TV Interface Device Switches with Coaxial Connectors

The following shall apply to measurement of transfer switch isolation if the antenna input port or terminal is intended for use with coaxial cable.

TV interface device transfer switch isolation is the difference between the levels, expressed in decibel units, of a signal going into one antenna input port of the switch and that of the same signal coming out of another antenna input port of the transfer switch. Be sure to compare emission levels of the same frequency.

The isolation of an antenna transfer switch of an unintentional radiator equipped with coaxial connectors shall be performed by measuring the maximum voltage of the visual carrier of the unintentional radiator present at the antenna input ports on the switch using the following procedure. The maximum voltage corresponds to the peak envelope power of a modulated signal during maximum amplitude peaks.

Place the unintentional radiator and its switch on a table 80 cm in height above ground. Using an impedance-matching device, if necessary, connect a length of coaxial cable between the antenna input port of the switch and the measuring instrument. Support the cable between the switch and the measuring instrument in a straight horizontal line so it has at least 75 cm clearance from any conducting surface. It may be necessary to connect a high-gain, low-noise amplifier between the impedance-matching device and the measuring instrument to increase the signal-to-noise ratio of the signal being measured.

Tune the measuring instrument to the output channel of the unintentional radiator, set the detector function to the peak mode, and adjust the bandwidth and attenuator settings to any convenient position to obtain sufficient signal-to-noise ratio. While applying the appropriate signals specified in 12.1.1, measure and record the voltage level present at the antenna input port of the TV interface device and the output channel of the TV interface device. For switch isolation measurements of a TV interface device, the video carrier of the device is the only signal that needs to be measured.

If the TV interface device operates on other output frequencies, repeat this procedure for all the output frequencies.

If the device or switch is equipped with more than two antenna input ports, repeat the procedure until isolation for each pair of antenna input ports has been measured. See 10.1.8.5 for reporting requirements.

NOTE — Only input ports on the device or switch intended for connection to an antenna are considered antenna input ports.

Additional guidance in step-by-step procedures for preparing, setting up, and carrying out the required measurements is contained in Appendix H8.

12.2.6.3 TV Interface Device Switches with Balanced Line Connectors

The following shall apply to measurement of the transfer switch isolation if the antenna input port or terminal is intended for use with a balanced line such as twin-lead.

The isolation of an antenna transfer switch of an unintentional radiator equipped with balanced line connectors shall be performed by measuring the maximum voltage of the visual carrier of the unintentional radiator present at the antenna input ports on the switch using the following procedure. The maximum voltage corresponds to the peak envelope power of a modulated signal during maximum amplitude peaks.

Place the unintentional radiator and its switch on a table 80 cm in height above ground. Connect a section of twin-lead whose length is $^3/_4$ of a wavelength of the TV interface device output channel frequency, between the antenna input port of the switch and a balanced RF voltmeter or a balun that is in turn connected to the measuring instrument.

Support the twin-lead between the switch and the measuring instrument in a straight horizontal line so it has at least 75 cm clearance from any conducting surface. It may be necessary to connect a high-gain, low-noise amplifier between the balun and the measuring instrument to increase the signal-to-noise ratio of the signal being measured.

Tune the measuring instrument to the output channel of the unintentional radiator, set the detector function to the peak mode, and adjust the bandwidth and attenuator settings to any convenient position to obtain sufficient signal-to-noise ratio. While applying the appropriate signal(s) specified in 12.1.1, measure and record the voltage level of the video carrier present at the antenna input port with 3/4 wavelength transmission line and with transmission lines of decreasing line length, in at least two equal decrements (total of three measurements, one each at 3/4, 1/2, and 1/4 transmission line length), to a length of 1/4 wavelength. For switch isolation measurements of a TV interface device, the video carrier of the device is the only signal that needs to be measured.

The isolation of a transfer switch that uses balanced transmission line is taken to be the median of the three values obtained in these measurements. Record the three measured levels, the output channel of the TV interface device, and the length of transmission line that produced each level.

If the TV interface device operates on other output frequencies, repeat this procedure for all the output frequencies. If the device or switch is equipped with more than two antenna input ports, repeat the procedure until isolation for each pair of antenna input ports has been measured. See 10.1.8.5 for reporting requirements.

NOTE — Only input ports on the device or switch intended for connection to an antenna are considered antenna input ports.

Additional guidance in step-by-step procedures for preparing, setting up, and carrying out the required measurements is contained in Appendix H8.

13. Measurement of Intentional Radiators

This section contains information applying specifically to intentional radiators, such as garage door opener transmitters and baby monitors. In general, testing is performed as specified in Sections 6 through 8 with the additions, specific clarifications, and exceptions described in this section.

This section prescribes many required procedures and guidelines designed to enhance repeatability. If a particular EUT cannot be tested according to these procedures, it is permissible to test the EUT in a manner dictated by good engineering judgment. Deviations from the prescribed procedure are permitted only where justified by typical usage but may require approval of the appropriate authority. Any deviations from the prescribed procedure shall be described and fully justified as outlined in 1.2 and 10.1.9.

Depending upon the operating frequency of the intentional radiator, measurements may be specified on the average, CISPR quasi-peak or peak basis, or a combination of these detector functions. Because of the complexity of the individual equipment requirements, careful study of these requirements is recommended before proceeding with testing.

13.1 Requirements of Intentional Radiators

This section contains information that applies only to the testing of intentional radiators.

13.1.1 Operating Conditions

The EUT shall be tested on the design frequency of the device. In the case of EUTs that can operate on more than one frequency, unless otherwise specified in the individual tests, measurements shall be made with the EUT set to a frequency or frequencies as provided in the following table:

Frequency range over which device operates	Number of frequencies	Location in the range of frequencies operation
Less than 1 MHz	1	Middle
1 to 10MHz	2	1 near top, 1 near bottom
More than 10 MHz	3	1 near top, 1 near middle, and 1 near bottom

Devices that use frequency-sweeping techniques shall have their frequency stopped at each of the frequencies specified above.

If the EUT transmits pulsed modulation, the modulation shall be adjusted to produce the maximum duty cycle possible during measurements.

13.1.1.1 Applied Modulation

Unless specified in the individual test instructions, typical modulation does not need to be applied during testing except when modulation is needed to produce a transmitted signal (e.g., single-sideband suppressed carrier transmitters). When modulation is specified in the individual tests, voice-only modulated devices (200 to 3000 Hz) except cordless telephones shall have a 1000 Hz tone at 100 dB SPL (sound pressure level) applied 10 cm from the microphone. (0 dB SPL is 20 μPa.) For a cordless telephone, the input signal shall be a 2500 Hz tone of sufficient level to produce 85% modulation. This will be construed as the level that produces 85% of the maximum obtainable frequency deviation measured at a point 26 dB down from the unmodulated carrier signal level (e.g., if the maximum obtainable frequency deviation is determined to be 5 kHz, then the input level that produces 4.25 kHz deviation would be utilized). The input signal shall be coupled directly to the audio input stage of the cordless telephone for both the base and remote unit. When modulation is required in an individual test, devices modulated from internal sources shall be tested with typical modulation applied. If a device is equipped with input connectors for external modulation, typical modulating signals shall be applied at the maximum rated input level for the device when modulation is required in an individual test (e.g., apply a 1000 Hz tone to an input for an external microphone).

13.1.2 Equipment Configurations

Follow the general guidelines in 6.2 for placement of the EUT, placement of accessories, and placement and manipulation of interconnecting cables and wires.

13.1.3 AC Powerline Conducted Emissions Tests

The following paragraphs describe the procedures that may be used for performing final ac powerline conducted emissions tests on intentional radiators. Additional guidance and step-by-step procedures for preparing the setups and carrying out the required ac powerline conducted tests for intentional radiators are contained in Appendix I.

13.1.3.1 Preliminary AC Powerline Conducted Emissions Tests

If the EUT uses a detachable antenna, these measurements shall be made with a suitable dummy load connected to the antenna output terminals; otherwise, the tests shall be made with the antenna connected and, if adjustable, fully extended. Preliminary tests shall be run both with the modulating signal(s) specified in 13.1.1.1 applied to the EUT and with no modulating signal applied to the EUT. On any one convenient frequency specified in 13.1.1, use the procedure in 7.2.3, while applying the appropriate modulating signal to the EUT, to determine the cable or wire position of the EUT system that produces the emission with the highest amplitude relative to the limit. This configuration will be used in final ac powerline conducted emissions testing of the EUT.

13.1.3.2 Final AC Powerline Conducted Emissions Measurements

Using the configuration of the EUT determined in 13.1.3.1, follow the procedure in 7.2.4, while applying the appropriate modulating signal to the EUT, to perform final ac powerline conducted emissions measurements.

Record the six highest EUT emissions relative to the limit of all the current-carrying conductors of the power cords that comprise the EUT over the frequency range specified by the procuring or regulatory agency. See 10.1.8.1 for reporting requirements. Diagram or photograph the test setup that was used (see 10.1.12).

13.1.4 Radiated Emissions Tests

The following paragraphs describe the procedures that may be used for performing final radiated emissions tests on intentional radiators. Additional guidance and step-by-step procedures for preparing the setups and carrying out the required radiated emissions tests for intentional radiators are contained in Appendix I.

13.1.4.1 Preliminary Radiated Emissions Tests

On the number of frequencies specified in 13.1.1, use the procedure in 8.3.1.1, while applying the appropriate modulating signal to the EUT, to determine cable or wire positions of the EUT system that produce the emission with the highest amplitude relative to the limit. An antenna shall be connected to the EUT. If the EUT is equipped with or uses an adjustable antenna, the EUT antenna shall be manipulated through typical positions and lengths during preliminary testing to maximize emission levels. In addition, preliminary radiated emissions testing shall be run as follows: (1) with the EUT powered in turn from both ac and dc (battery) power, if the device has these capabilities; (2) with the EUT supplied in turn with the appropriate modulation specified in 13.1.1.1 and without modulation; and (3) with hand-held or bodyworn devices rotated through three orthogonal axes to determine which attitude and configuration produces the highest emission relative to the limit. The attitude and configuration that produces the highest emission relative to the limit will be used in final radiated emissions testing of the EUT.

13.1.4.2 Final Radiated Emissions Measurements

Using the attitude and configuration of the EUT determined in 13.1.4.1, follow the procedure in 8.3.1.2, while applying the appropriate modulating signal to the EUT, to perform final radiated emissions measurements on the number of frequencies specified in 13.1.1.

On each of the frequencies to which the device is tuned, record the frequency and amplitude of the highest fundamental emission, the frequency and amplitude of the three highest harmonic or spurious emissions relative to the limit, and the frequency and amplitude of the three highest restricted band emissions relative to the limit. See 10.1.8.2 for reporting requirements. Diagram or photograph the test setup that was used (see 10.1.12).

NOTE — For the purposes of this document, spurious emissions shall include out-of-band emissions typically associated with or generated by the modulating signal.

Devices transmitting pulsed emissions and subject to a limit requiring an average detector function for radiated emissions shall initially be measured with an instrument that uses a peak detector. A radiated emissions measured with a peak detector may then be corrected to a true average using the appropriate factor for emission duty cycle. This correction factor relates the measured peak level to the average limit and is derived by averaging absolute field strength over one complete pulse train that is 0.1 s, or less, in length. If the pulse train is longer than 0.1 s, then the average shall be determined from the average absolute field strength during the 0.1 s interval in which the field strength is at a maximum. Instructions on calculating the duty cycle of a transmitter with pulsed emissions are provided in Appendix 14, step 10.

NOTE — The bandwidth of the measuring instrument shall be wider than the pulse repetition frequency of the transmitted signal in order to measure its maximum peak level. See [18] for guidelines en selecting bandwidth and determining pulse desensitization factors, as necessary.

13.1.5 Operating Frequency Measurements

If required, the operating or transmitting frequency of an intentional radiator should be measured in accordance with the following procedure to ensure that the device operates (1) outside certain precluded frequency bands and (2) within the frequency range. No modulation needs to be supplied to the intentional radiator during these tests, unless modulation is required to produce an output, e.g., single-sideband suppressed carrier transmitters.

Operating frequency measurements may be made at ambient room temperature if it is within the range of +15° to +25° C; otherwise, an environmental temperature test chamber set for a temperature of +20° C shall be used. If possible, an antenna should be connected to the EUT since use of a dummy lead could affect the output frequency of the EUT. If the EUT is equipped with or uses an adjustable-length antenna, it should be fully extended.

Position the intentional radiator as specified in 6.2. Supply the EUT with nominal ac voltage or install a new or fully charged battery in the EUT. Turn the EUT on and couple its output to the measuring instrument by connecting an antenna to the measurement instrument with a suitable length of coaxial cable.

NOTE — A frequency counter or other frequency-measuring device that has an adequate level of accuracy as specified by the procuring or regulatory agency is the recommended measuring instrument.

Adjust the location of the measurement antenna and the controls on the measuring instrument to obtain a suitable signal level (i.e., a level that will not overload the measuring instrument, but is strong enough to allow measurement of the operating or fundamental frequency of the EUT).

Tune the EUT to any one of the number of frequencies specified in 18.1.1. Turn the EUT off and place it inside an environmental chamber if appropriate. Allow the chamber to stabilize at +20 deg;C before proceeding. Turn on the EUT and record the operating frequency of the intentional radiator at startup and two, five, and ten minutes after startup.

Turn the EUT off and allow it to cool down to the ambient temperature, then repeat this procedure for the number of the frequencies specified in 13.1.1. Four measurements are made at each operating frequency. See 10.1.8.6 for reporting requirements.

Additional guidance in step-by-step procedures for preparing, setting up, and carrying out the required measurements is contained in Appendix I5.1.

13.1.6 Frequency Stability Measurements

When frequency stability measurements on an intentional radiator are required, the following procedures of this section should be used. No modulation needs to be supplied to the intentional radiator during these tests, unless modulation is required to produce an output, e.g., single-sideband suppressed carrier transmitters.

13.1.6.1 Stability with Respect to Ambient Temperature

Supply the EUT with nominal ac voltage or install a new or fully charged battery in the EUT. If possible, a dummy load should be connected to the EUT since an antenna near the metallic walls of an environmental test chamber could affect the output frequency of the EUT. If the EUT is equipped with a permanently attached, adjustable-length antenna, the EUT should be placed in the center of the chamber with the antenna adjusted to the shortest length possible. Turn the EUT on and tune it to one of the number of frequencies required in 13.1.1.

Couple the intentional radiator output to the measuring instrument by connecting an antenna to the measurement instrument with a suitable length of coaxial cable and placing the measurement antenna near the EUT (e.g., 15 cm away) or by connecting a dummy load to the measuring instrument through an attenuator, if necessary.

NOTE — An instrument that has an adequate level of accuracy as specified by the procuring or regulatory agency is the recommended measuring instrument.

Adjust the location of the measurement antenna and the controls on the measuring instrument to obtain a suitable signal level (i.e., a level that will not overload the measuring instrument, but is strong enough to allow measurement of the operating or fundamental frequency of the EUT).

Turn the EUT off and place it inside an environmental temperature chamber. For devices that are normally operated continuously, the EUT may be energized while inside the test chamber. For devices that have oscillator heaters, energize only the heater circuit while the EUT is inside the chamber.

Set the temperature control on the chamber to the highest specified EUT operating temperature and allow the temperature inside the chamber to stabilize at the set temperature before starting frequency measurements.

While maintaining a constant temperature inside the environmental chamber, turn the EUT on and record the operating frequency at startup and two, five, and ten minutes after the EUT is energized. Four measurements in total are made.

Repeat the above procedure until the number of frequencies specified in 13.1.1 have been measured. After all measurements have been made at the highest specified temperature, turn the EUT off.

Repeat the above measurement process for the EUT with the test chamber set at the lowest temperature specified by the regulatory or procuring agency. Measurements shall be made at the number of frequencies specified in 13.1.1. See 10.1.8.7 for reporting requirements.

Additional guidance in step-by-step procedures for preparing, setting up, and carrying out the required measurements is contained in Appendix 15.2.

13.1.6.2 Stability with Respect to Input Voltage

These measurements may be made at ambient room temperature if it is within the range of +15° to +25 °C; otherwise, an environmental temperature test chamber set for a temperature of +20 °C shall be used. An antenna should be connected to the antenna output terminals of the EUT if possible. If the EUT is equipped with or uses an adjustable-length antenna, it should be fully extended.

Position the intentional radiator as specified in 6.2. Supply the EUT with nominal ac voltage or install a new or fully charged battery in the EUT. Turn on the EUT and couple its output to a frequency counter or other frequency-measuring instrument.

NOTE — An instrument that has an adequate level of accuracy as specified by the procuring or regulatory agency is the recommended measuring instrument.

Tune the EUT to one of the number of frequencies required in 13.11. Adjust the location of the measurement antenna and the controls on the measuring instrument to obtain a suitable signal level (i.e., a level that will not overload the measuring instrument, but is strong enough to allow measurement of the operating or fundamental frequency of the EUT).

Turn the EUT off and place it in an environmental chamber if appropriate. Allow sufficient time for the chamber to stabilize at +20 °C before proceeding. Turn the EUT on and measure the EUT operating frequency at startup, and two, five, and ten minutes after startup. For battery and ac-powered devices, repeat the above procedure until the number of frequencies specified in 13.1.1 have been measured.

If the EUT is powered from the ac powerlines, supply it with 85% of the nominal ac voltage and repeat the above procedure for the number of frequencies specified in 13.1.1. If the EUT is battery-operated, see 10.1.8.7 for reporting requirements.

If the EUT is powered from the ac powerlines, supply it with 115% of the nominal ac voltage and repeat the above procedure for the number of frequencies specified in 13.1.1. Allow the environmental chamber temperature to stabilize before proceeding. See 10.1.8.7 for reporting requirements.

Additional guidance in step-by-step procedures for preparing, setting up, and carrying out the required measurements is contained in Appendix I5.3.

13.1.7 Occupied Bandwidth Measurements

When occupied bandwidth measurements on an intentional radiator are required, the following procedures of this section should be used.

The bandwidth is measured at an amplitude level reduced from the reference level by a specified ratio. The reference level is the level of the highest amplitude signal observed from the transmitter at either the fundamental frequency or first-order modulation products in all typical modes of operation, including the unmodulated carrier, even if atypical. Once the reference level is established, the equipment is conditioned with typical modulating signals to produce the worst-case (i.e., the widest) bandwidth. If no bandwidth requirement is specified by the procuring or regulatory agency, then measure the bandwidth at –26 dB with respect to the reference level.

In order to measure the modulated signal properly, a resolution bandwidth that is small compared to the bandwidth required by the procuring or regulatory agency shall be used on the measuring instrument. However, the 6 dB resolution bandwidth of the measuring instrument shall be set to a value greater than 5% of the bandwidth requirements. When no bandwidth requirements are specified, the minimum 6 dB resolution bandwidth of the measuring instrument is given in the following table:

Fundamental Frequency	Minimum Resolution Bandwidth
9 kHz to 30 MHz	1 kHz
30 MHz to 1000 MHz	10 kHz
1000 MHz to 40 GHz	100 kHz

NOTE — At the frequency range boundaries, the smaller resolution bandwidth shall be used.

Position the intentional radiator as specified in 6.2.

Supply the EUT with nominal ac voltage or install a new or fully charged battery in the EUT. Turn the EUT on and set it to any convenient frequency within its operating range. Set a reference level on the measuring instrument at any location that will allow measuring the specified bandwidth (e.g., –26 dB below the unmodulated carrier).

Supply the EUT with modulation as specified in 13.1.1.1. Observe and record with plotted graphs or photographs the worst-case (i.e., widest) occupied bandwidth produced by these different modulation sources. See 10.1.8.8 for reporting requirements.

Additional guidance in step-by-step procedures for preparing, setting up, and carrying out the required measurements is contained in Appendix 16.

13.1.8 Input Power Measurements

When required, the input power to either an intentional radiator or the final RF stage (exclusive of filament or heater power) of an intentional radiator should be measured using the following procedure.

Position the intentional radiator as specified in 6.2. Supply the EUT with nominal ac voltage or install a new or fully charged battery in the EUT. Typical modulation shall be applied to the EUT during these tests. If the EUT accepts modulation from multiple sources, each modulation source shall be applied individually to determine which produces the highest input power level.

Select any one convenient operating frequency of the intentional radiator. For input power measurements for an intentional radiator, use a voltmeter and ammeter and measure the voltage and current at the ac or battery input terminals to the intentional radiator. For input power measurements to the final RF stage, use adc voltmeter and ammeter and measure the voltage and current at the input to the final amplifier stage of the intentional radiator. The input power is the product of the measured voltage and current. See 10.1.8.9 for reporting requirements.

Additional guidance in step-by-step procedures for preparing, setting up, and carrying out the required measurements is contained in Appendix 17.

14. Limit Relaxation for Transients

For many devices, transients of short duration repeated infrequently do not cause significant interference. For this reason, (when permitted by the responsible agency), when transients whose individual durations do not exceed 200 ms (i.e., “clicks” as used in CISPR Publication 16-1987 [6]) occur and exceed the radiated or conducted limit for continuous disturbances, unless otherwise specified, the limit can be relaxed for the transients according to the following table where *N* is the number of clicks/minute above the limit:

Click Rate *N*	**Relaxation, dB**
≤ 0.2	44
$0.2 < N < 30$	$20\log\left(\frac{30}{N}\right)$
≥ 30	0

The EUT is compliant if no more than 25% of the clicks (that exceed the basic limit) exceed the relaxed limit.

15. Bibliography

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Annex A Site Attenuation Using Discrete Frequencies

(Informative)

(These appendixes are not a part of ANSI C63.4-1992, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz, but are included for information only.)

The discrete frequency method is performed using a worksheet approach [B12]. The sample worksheet (1) sequences the site attenuation measurements, (2) directs the application of various corrections, and finally (3) provides a method for comparing deviations of the measured NSA data from the NSA for an ideal site. Figure A1 contains the recommended worksheet for making the measured NSA comparisons with the values for the ideal site obtained in Tables 1 through 3. The entries are used for solving Eq 1 (5.4.6.4). The entries for each column are as follows:

Column 1: Frequency between 30-1000 MHz in steps indicated in Tables 1 through 3.

Column 2: The polarization of both transmit and receive antennas with respect to the conducting ground plane.

Column 3: V_{Direct} is the level at the receiver or spectrum analyzer when the coaxial feed lines connected to each antenna are directly connected together (points 1 and 2 connected in Figs 6 and 7). [dB(μV)]

Column 4: V_{Site} is the level measured at the receiver or spectrum analyzer when the receive antenna is searched in height for the maximum transmitted signal that is required for site attenuation measurements. The level of the signal generator is the same as for the column 3 measurement. [dB(μV)]

Column 5: ΔAF_{TOT} = 0 for all vertical and horizontal site attenuation measurements made at separations of 10 and 30 m for tunable dipoles and for all other measurements using broadband antennas. ΔAF_{TOT} is not equal to 0 for site attenuation measurements at 3 m separation using tunable dipoles (see Table 4 for these mutual coupling corrections). [dB]

Column 6: A = Site attenuation (algebraic sum of column 3 less column 4). [dB]

Column 7: AF_T = Transmit antenna factor (accurately measured for this antenna). [dB (l/m)]

Column 8: AF_R = Receive antenna factor (accurately measured for this antenna). [dB (l/m)]

Column 9: A_N = Measured normalized site attenuation-NSA (column 6 less column 7 less column 8). This is equivalent to A_N given by Eq 1. [(dB)]

Column 10: Theoretical NSA (see appropriate values for site attenuation geometry and antennas used in Tables 1 through 3).

Column 11: Deviation = column 10 less column 9. [(dB)]

(1) Frequency (MHz)	(2) Polarization H or V	(3) V_{DIRECT} dB (μV)	(4) V_{SITE} dB (μV)	(5) ΔAF_{TOT} See Table 4 dB	(6) Adjusted Site Attenuation dB	(7) AF_{TX} dB (1/m)	(8) AF_{RX} dB (1/m)	(9) A_N (NSA) Measured dB $(1/m)^2$	(10) A_N (NSA) Theoretical dB $(1/m)^2$	(11) Deviation dB

Note: (6)=(3)–(4)–(5) (9)=(6)–(7)–(8) (10)=See Tables 1–3 (11)=(10)–(9)	REMARKS:

Figure A1 —Site Attenuation Worksheet

Table A1 is an example of the use of the worksheet. Consider a 3 m separation horizontal site attenuation measurement using tunable resonant half-wave dipoles at 80 MHz.

Table A1 —Example of Worksheet Entries

Column	Entry
1	80 MHz frequency
2	Horizontal (polarization)
3	81.5 dB(μV) (assumed value)
	Receiver/spectrum analyzer
	reading with coaxial cables connected
4	67.5 dB(μV) (assumed value)
	Receiver/spectrum analyzer reading with
	receiver signal maximized by searching the
	height between 1 and 4 m
5	−1.0 dB (from Table 4)
6	15.0 dB [81.5—67.5 −(−) 1.0]
7	6.7 dB assumed from calibration curve
8	6.5 dB assumed from calibration curve
9	1.8 dB [15.0 −6.7—6.5]
10	−0.7 dB (from Table 2)
11	−2.5 dB [−0.7 −(1.8)] (calculated deviation from model)

NOTE — The column 6 value of 15.0 dB is equivalent to the site attenuation for tunable resonant half-wave dipoles. The NSA removes the antenna factor and allows the comparison with the NSA for an ideal site. Column 11, hence, gives a deviation amplitude of 2.5 dB with respect to the ideal site attenuation.

In the example given in Table A1, the 2.5 dB falls well within the +4 dB range and indicates site acceptability and probably a less than 1 dB site imperfection at 80 MHz, which is quite good.

Annex B Site Attenuation Using Swept Frequencies

(Informative)

Swept frequency method measurements may be made using broadband antennas and a spectrum analyzer with a peak hold, maximum hold, or storage capability, and a tracking generator. This method does not require the use of a worksheet since all comparisons are made with spectrum analyzer traces and separately constructed plots.

1) Adjust the output level of the tracking generator to give a received voltage display well above ambient and spectrum analyzer noise, but not so high as to overload the spectrum analyzer.
2) Raise the receiving antenna on the mast to the maximum height of the scan range as indicated in the appropriate Table, 1, 2, or 3.
3) Set the spectrum analyzer to sweep the desired frequency range. Ensure that the spectrum analyzer is adjusted so that a similar signal up to 60 dB higher can be displayed on the same amplitude scale. This will accommodate the levels to be recorded in step 5.
4) Slowly lower the receiving antenna to the minimum height of the scan range as indicated in the tables for the appropriate site geometry. Store or record the maximum received voltage display in dB(μV). (The time it takes to lower the antenna should be much longer than the spectrum analyzer sweep time.)
5) Disconnect the transmit and receive cables from the antennas and connect directly together with a straight-through adapter. Store or record the resulting voltage display.
6) At each frequency, subtract the voltage measured in step 4 from the voltage measured in step 5. Also subtract the antenna factors for the transmit and receive antennas, AF_R and AF_T (dB/m), respectively. (Antenna factors as a continuous function of frequency can be obtained using the standard site method for calibrating antennas described in ANSI C63.5-1988 [2] or by using simple linear curve fitting on a set of discrete antenna factor values.) The result is the measured NSA over the range of frequencies used, which should be plotted. Also plot the theoretical NSA for an ideal site. If this process is carried out automatically in the analyzer, the accuracy of the analyzer to perform these calculations shall be confirmed.

Annex C Site Attenuation Deviations

(Informative)

If the deviation exceeds the ± 4 dB criterion, investigate as follows:

Start by checking the measurement system calibrations. If the signal generator and receiver/spectrum analyzer do not drift during the measurements, the prime suspects are the antenna factors. If these all check out, repeat the measurement.[10] If the differences are still greater than +4 dB, the site, the surrounding area, and the antenna and cabling placement are suspect. The vertical site attenuation should in general be the most sensitive to site anomalies. If so, use that measurement as the basis for tracking down the problem. Problems that may be found include inadequate conducting ground plane construction and size, reflecting objects too close by (fences, buildings, light towers, etc.), and degraded performance of all-weather enclosures due to inadequate construction techniques and such long-term problems as penetration of residue from airborne conductive contaminants (ANSI C63.6-1988 [3] and ANSI C63.7-1988 [4]).

[10]Consider adding the 10 dB pads indicated in the NOTE in 5.4.6.4 (third to last paragraph), especially if the antennas are suspected of having a relatively high voltage-standing wave ratio (VSWR).

Annex D Method of Preliminary Radiated Emissions Maximization

(Informative)

The maximum radiated emission for a given mode of operation may be found during preliminary testing, by using the following step-by-step procedure:

1) Monitor the frequency range of interest at a fixed antenna height and EUT azimuth.
2) If appropriate, manipulate the system cables to produce the highest amplitude signal relative to the limit. Note the amplitude and frequency of the suspect signal.
3) Rotate the EUT 360 to maximize the suspected highest amplitude signal. If the signal or another at a different frequency is observed to exceed the previously noted highest amplitude signal by 1 dB or more, go back to the azimuth and repeat step 2. Otherwise, orient the EUT azimuth to repeat the highest amplitude observation and proceed.
4) Move the antenna over its full allowed range of travel to maximize the suspected highest amplitude signal. If the signal or another at a different frequency is observed to exceed the previously noted highest amplitude signal by 1 dB or more, return to step 2 with the antenna fixed at this height. Otherwise, move the antenna to the height that repeats the highest amplitude observation and proceed.
5) Change the polarity of the antenna and repeat steps 2 through 4. Compare the resulting suspected highest amplitude signal with that found for the other polarity. Select and note the higher of the two signals. This signal is termed the highest observed signal with respect to the limit for this EUT operational mode.
6) The effects of various modes of operation shall be examined. One way to do this is to vary the equipment modes as steps 2 through 5 are being performed.
7) After completing steps 1 through 6, record the final EUT configuration, mode of operation, and cable configuration to use for the final radiated emissions test in 8.3.1.2.

Annex E Step-by-Step Guidance for Testing Personal Computers and Associated Peripherals

(Informative)

The following procedure may be used as a guide for determining compliance of a personal computer or associated peripherals with certain regulatory requirements. The section numbers refer to sections or subsections in this standard. This procedure may also be used as a guide for measuring other devices, as appropriate.

E.1 AC Powerline Conducted Setup

1) The ac powerline conducted test facility shall conform to the requirements of 5.25.2.3 and 7.2-7.2.2. The measuring instruments, including the LISN, shall conform to the requirements in Section 4.
2) The EUT shall be configured in accordance with 6-6.2.3.3 and 11.1-11.2.4.
3) Use the type and length of interface cables specified in 6.1.4 and connect them to the interface ports on the EUT in accordance with 6.1.3. Interface cables shall be individually bundled as described in 6.1.4 and 11.2.4. The bundle should be secured with masking tape or any other nonconducting material that will not affect the measurements.
4) Connect the EUT to one LISN and connect the peripheral or support equipment to a separate LISN as described in 7.2.1. AC power for all LISNs is to be obtained from the same ac source.

   NOTE — As noted in 11.2.4, the monitor shall be powered by two separate sources as follows: (1) a second LISN, and (2) an ac outlet provided on the back of the personal computer, if appropriate. When a personal computer is equipped with an ac outlet on its back, two preliminary tests are needed to determine whichconfiguration produces maximum emission levels.

   If the EUT power cord is long enough to be bundled, the bundle should be secured with masking tape or any other nonconducting material that will not affect the measurements. Power cords of non-EUT equipment do not require bundling. Drape ac power cords of non-EUT equipment over the rear edge of the table and route them down onto the floor of the conducted test site to the second LISN. Power cords of peripheral equipment should not be draped over the top of an LISN.

E.2 AC Powerline Conducted Emissions Testing

1) Check the calibration of the measuring instrument using either an internal calibrator or a known signal level from an external signal generator.
2) A spectrum analyzer or other instrument providing a spectral display is recommended for preliminary conducted measurements. Connect the measuring instrument to the RF port of a section of the LISN supplying current to one of the conductors in the EUT using a suitable length of coaxial cable. Terminate all other RF ports on the LISNs in 50 Ω resistive. Set the 6 dB bandwidth of the measuring instrument to not less than 10 kHz and the detector function to the peak mode. Set the controls on the measuring instrument to enable viewing the entire frequency range for which limits are specified.
3) Activate the EUT and the measuring instrument to meet the requirements of 6.1.9.
4) Exercise the EUT as specified in 6.1 and 11.1. Accessory equipment connected to the EUT shall be exercised independently.
5) Follow the procedure in 7.2.3, and use the configuration in 11.2 to produce the emission that has the highest amplitude relative to the limit. The EUT may be turned off and on to determine which emissions originate from it.
6) Repeat step 5 with the measuring instrument connected to the RF port of the other LISN section supplying the EUT with ac power.
7) Select the EUT configuration and mode of operation that produced the highest emission relative to the limit for final ac powerline conducted emissions measurement. If the EUT is moved to a final ac powerline conducted test site from a preliminary conducted test site, be sure to remaximize the highest emission

according to 7.2.4. Set the bandwidth and the detector function of the instrument as specified in Section 4. Follow the procedure in 11.5.2 to measure the final ac powerline conducted emissions from the EUT.

8) Repeat step 7 with the measuring instrument connected to the RF port of the other LISN section supplying the EUT with ac power.

NOTE — Measurements are to be made only on emanations available at the RF ports of the LISNs connected to the EUT.

9) Record the EUT configuration, mode of operation, and cable configuration used for final ac powerline conducted emissions tests. This can be done with either diagrams or photographs.

10) Prepare the final test report data in accordance with Section 10.

E.3 Radiated Test Setup

1) Preliminary radiated measurements should generally follow procedures in Sections 8 and 11. The measuring instruments shall conform to the requirements in Section 4.
2) The EUT shall be placed on a turntable as specified in 5.4.4 and configured as in steps 2 and 3 of the E1 ac powerline conducted test setup.
3) Connect the power cords of the EUT and non-EUT equipment to the ac power source. The EUT power cord is to be connected directly to an ac outlet on the turntable for these measurements even if the EUT normally receives power through another device in the system.

NOTE — The monitor shall be powered by two separate sources as follows: (1) an ac outlet on the rotator surface, and (2) an ac outlet provided en the back of the personal computer, if appropriate. When a personal computer is equipped with an ac outlet on its back, two preliminary tests will be needed to determine which configuration produces maximum emission levels.

AC power cords of the EUT or non-EUT equipment do not require bundling. Drape all ac power cords of equipment tested on a tabletop over the rear edge of the table and route them down onto the turntable surface to the ac outlet. Refer to FigFig 9(d)—(c).

E.4 Radiated Emissions Testing

1) Check the calibration of the measuring instrument using either an internal calibrator or a known signal level from an external signal generator.
2) A spectrum analyzer or other instrument providing a spectral display is recommended for preliminary radiated measurements. The frequency range may be scanned in segments or in its entirety depending upon the rated frequency range of the measurement antenna (see NOTE under step 5 below). Set the 6 dB bandwidth of the measuring instrument to 100 kHz and the detector function to the peak mode. Set the display on the measuring instrument to enable viewing of emissions between 30 MHz and 230 MHz by setting the scan width control on the analyzer to 20 MHz per division. Adjust the sweep speed control so the analyzer display is calibrated. Video filtering is not used during these tests.

NOTE — If ambient radio or TV signals are of such magnitude or spacing that emissions from the EUT may be hidden, the scan width control can be set to 10 MHz per division or lower to identify EUT emissions. Use of a bandwidth less than 100 kHz may be helpful.

3) Activate the EUT and the measuring instrument to meet the requirements of 6.1.9.
4) Exercise the EUT as specified in 6.1 and 11.1. Equipment connected to the EUT shall be exercised independently.
5) Use a procedure such as the one contained in Appendix D to maximize emissions from the EUT that are displayed on the analyzer and note the EUT configuration as described in Section 11, mode of operation, and cable positions that produce the highest emission relative to the limit.

NOTE — A broadband antenna is recommended for preliminary scanning of radiated emissions. It will be necessary to change to other measurement antennas during this process to stay within the frequency range of the measurement antenna.

6) Tune the spectrum analyzer to the next segment of the frequency spectrum to be scanned and repeat steps 3 through 6 until the frequency range of interest has been investigated.
7) Select the EUT configuration, mode of operation, and interconnect cable positions from step 5 that produced the highest emission relative to the limit for use in final radiated measurements. The final radiated emissions

test facility shall conform to the requirements of 5.4 and 5.4.1. Set the bandwidth and the detector function of the instrument as specified in Section 4.

8) It is recommended that the highest emission relative to the limit be remaximized according to 8.3.1.2 before performing final measurements, even if the EUT is not moved from a preliminary to a final radiated test site because slight variations in cable position can cause large variations in signal amplitude. Only slight variation in cable movements should be needed to remaximize the highest emission again.

   NOTE — The same measurement antenna and distance should be used for remaximizing the highest signal relative to the limit at the final radiated emissions test site.

9) Place the measurement antenna specified in 4.1.5 the distance from the EUT specified in the appropriate regulations.

10) Follow the procedure in 11.6.2 to measure radiated emissions from the EUT.

    NOTE — It will be necessary to change to other measurement antennas during this process to stay within the frequency range of the measurement antenna.

    If regulations do not require radiated measurements above 1 GHz, proceed to step 13. If radiated measurements above 1 GHz are required, an instrument capable of measuring both peak and average detector function signals shall be used. Set the bandwidth of this instrument to 1 MHz and the detector function to the peak mode. Measure emissions above 1 GHz from the EUT by following the procedures in 8.2.4 and 11.6.2.

11) If all of the emission levels above 1 GHz, as measured with the peak detector function, comply with the average limit specified by the appropriate regulations, proceed to step 13. If any of these emission levels exceed the average limits but comply with the peak limits, proceed to step 12.

12) Set the detector function of the measuring instrument to the average mode, using the procedures described in 8.2.4 and 11.6.2, and remeasure only those emissions from step 11 that complied with the peak limits but exceeded the average limits.

13) Record the EUT configuration, mode of operation, and cable positions used for final radiated emissions measurements. This can be done with either diagrams or photographs.

14) Prepare the final test report data in accordance with Section 10.

Annex F Verification of LISN Characteristics

(Informative)

The impedance and insertion loss of each LISN section is to be measured at least once a year using the following or equivalent procedure. The measurements are to be made at a sufficient number of frequencies to obtain a smooth curve of impedance or insertion loss with frequency.

F.1 Measuring the Impedance of an LISN

1) This measurement is to be made with the LISN installed for use in testing a device.
2) To avoid possible introduction of ac power from the supply line into the measuring instrument, disconnect the power connections (both neutral and hot lines) to the LISN at the line side of the LISN. If an RF filter is used to eliminate high ambient conducted signals, it should remain connected to the LISN for these tests since the impedance of the RF filter can have an effect on the LISN impedance. If an RF filter is used, disconnect the power connections (both the hot and neutral lines) to the LISN at the line side of the RF filter.
3) Connect a 50 Ω termination on each port of the LISN.
4) The preferred instrument for measuring LISN impedance is a scalar network analyzer that can be tuned continuously over the frequency range of the test. A vector impedance meter or vector network analyzer may also be used. If an instrument that is not continuously tunable is used (such as an RF bridge that is capable only of measuring the impedance at a selected frequency), care should be exercised to make measurements at frequency intervals close enough together, particularly above 20 MHz, so that any resonances can be detected.Using a suitable low-impedance adapter, connect the measuring instrument directly to one terminal of the ac outlet on the load side of the LISN normally used to supply power to the EUT or peripheral, and measure the impedance to that side of the LISN, tuning the instrument over the frequency range so as to detect any impedance variations that may be due to resonances or other imperfections.
5) Plot the measured impedance curve for comparison with the tolerances shown on Fig 1. If any measured value exceeds the permissible error tolerance, the LISN shall be modified to reduce the error to an acceptable level.
6) Repeat step 4 with the measuring instrument connected to the other side of the LISN.
7) If the LISN has more than two sections, repeat step 4 for all the additional sections.
8) If the LISN inductors have magnetic materials in their construction, make additional tests with ac current applied through the LISN to ensure that any variability due to effects of line current can be detected. This can most easily be accomplished by shorting together the load terminals of the two sides of the LISN and feeding current into the line terminals from a low-voltage transformer of suitable current rating. An ac ammeter in series with the circuit can be used to measure the applied current and a variable transformer can be used to regulate the amount of current by varying the primary voltage of the transformer. The highcurrent circuit should not have a ground connection. Note that the impedance values measured by this technique will be approximately one-half of those observed in steps 5 and 6.
9) The above procedure is to be repeated for each LISN used for conducted measurements.

F.2 Measuring the Insertion Loss of LISN

The following is the procedure for using a radio-noise meter (receiver) and a signal generator:

1) Set up the LISN and test equipment as shown in Fig Fl(a).
2) With the equipment connected as shown and a 50 Ω termination on the T-connector (A), measure the received signal voltage V_L in dB (μV) at the RF port (B).
3) Leaving the RF output of the signal generator unchanged, transfer the 50 Ω measuring termination to the RF port (B) and transfer the receiver input cable to the T-connector (A). Measure the drive signal voltage V_D in dB (μV).
4) Subtract V_L from V_D to obtain the insertion loss (in dB) of the LISN.

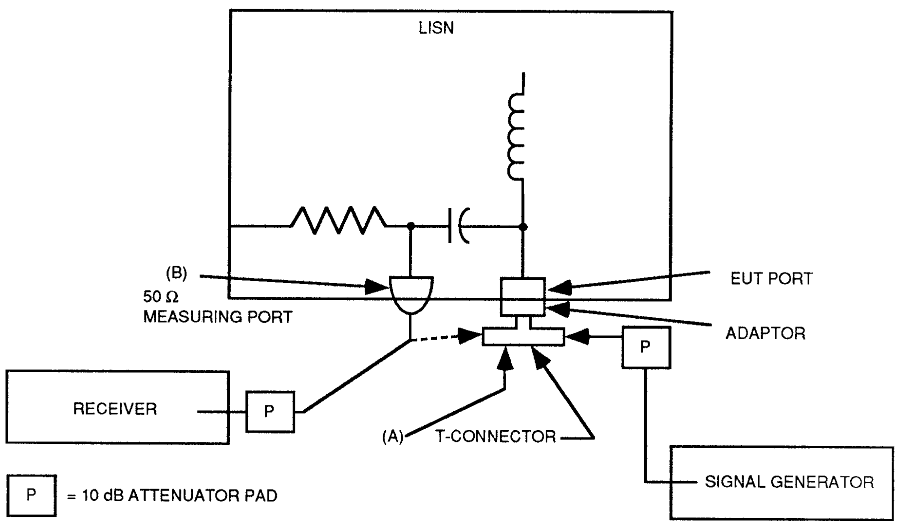
The following is the procedure for using a network analyzer:

1) Calibrate the network analyzer with the cables to be used in the measurements.
2) Set up the LISN and test equipment as shown in Fig Fl(b).
3) Subtract the signal level (in dB) in the reference channel from the signal level (in dB) in the test channel to obtain the insertion loss (in dB) of the LISN.

NOTES:

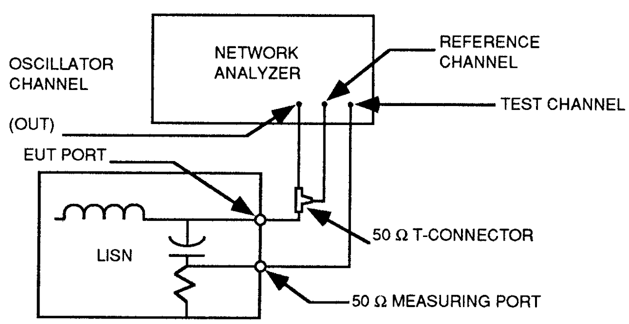
1 — Attenuator pads are not used with the network analyzer because the impedances of the channels in the network analyzer are very nearly 50 W and any errors are corrected during calibration. Attenuator pads may be used if desired, but including them complicates the network analyzer calibration.

2 — In this document, when the term LISN is mentioned, it means an LISN set with two or more sections, as necessary.



NOTE: If VSWR of receiver and signal generator is low, pads may not be needed or may be reduced to 6 dB or 3 dB.

(a) Method Using Receiver and Signal Generator



NOTE: Attenuator pads not used with network analyzer. Place T-connector as close to EUT port as possible. Use same length and type of cables between T-connector and reference channel input and 50 Ω measuring port and test channel input.

(b) Method Using Network Analyzer

Figure F1 —Measurement of LISN Insertion Loss

Annex G Absorbing Clamp

(Informative)

The absorbing clamp has been developed and is recommended by the International Special Committee on Radio Interference (CISPR) for use in the 30 MHz to 300 MHz frequency range [(CISPR Publication 16 (1987) [6], paragraph 11)]. The absorbing clamp measuring procedure is based upon the assumption that at frequencies above 30 MHz, radio noise is radiated from the ac powerline connected to the EUT, and not from the EUT itself.

G.1 Description

With reference to Fig 14, the absorbing clamp utilizes ferrite rings or cores that surround the power cord and the shielded line leading to the radio-noise meter to stabilize the impedance seen by the EUT at approximately 150 W in the frequency range from 30 to 300 MHz and to attenuate ambient noise originating on the power system. The current transformer uses similar ferrite cores or rings that are linked by a one-turn loop feeding the coaxial cable to the measuring instrument. The voltage read en the measuring instrument is proportional, at any frequency, to the RF current on the power cord at the location of the current transformer.

G.2 Calibration

1) The EUT in Fig 14 is replaced with a signal generator located just inside the wall of a screened room or behind a vertical conducting surface of at least 2.5 m by 2.5 m.
2) The signal generator is connected to a coaxial connector in the wall or conducting surface through a 10 dB pad. On the other side of the wall, a single cable is stretched outside the room from the center pin of the connector so as to replace the power cord in Fig Fig 14—.
3) The single cable shall be positioned in the center of the current transformer part of the clamp. It shall not be close to the slit between ferrite ring halves in the remainder of the clamp. The calibration procedures used shall be clearly identified. Where calibration curves (manufacturer's or any other) are used, they shall be referenced or included with the results.
4) Adjust the position of the clamp along the cable for maximum received signal at each frequency. The calibration is determined by comparing the receiver indication with the output of the signal generator, while taking the attenuator into account.

Annex H Step-by-Step Guidance for Testing Unintentional Radiators Other than ITE (Informative)

The following procedures may be used as a guide for determining compliance with certain regulatory requirements of unintentional radiators that can be tested on an open field test site. The section numbers refer to sections or subsections in this standard.

H.1 AC Powerline Conducted Setup

1) The ac powerline conducted test facility shall conform to the requirements of 5.2–5.2.3 and 7.2–7.2.2. The measuring instruments, including the LISN, shall conform to the requirements in Section 4.
2) The EUT shall be configured in accordance with 6–6.2.3.3 and 12.1–12.1.2 or 12.1–12.2.2 as appropriate.
   If the EUT uses a detachable antenna, ac powerline conducted measurements may be made with a suitable dummy load connected to the EUT antenna output terminals; otherwise, these tests shall be made with the antenna connected and, if adjustable, fully extended.
3) If the EUT is a receiver, it shall be supplied with the conditioning signal specified in 12.1.1.1 or 12.1.1.2, as applicable. The conditioning signal may be applied to the EUT by radiation or conduction on any convenient frequency specified in 12.1.1.
   If the EUT is a TV interface device, it shall be operated with typical signals applied, as specified in 12.2.1.1–12.2.1.4, as appropriate.
4) All input terminals or connectors on an unintentional radiator shall be terminated in the proper impedance. The output ports or connectors of a TV interface device shall be connected to either (a) the cable provided with the device or (b) a cable of typical length. This output cable shall be connected to either a terminating resistor of the proper impedance or the antenna transfer switch provided with the device. All other antenna transfer switch ports shall be terminated in the proper impedance.Support the cable in a straight horizontal line between the EUT and termination by placing it on a table. There should be at least 75 cm clearance from any other conducting object.
5) Connect the EUT power cord to one LISN and connect the peripheral or support equipment power cords to a separate LISN as described in 7.2.1. AC power for all LISNs is to be obtained from the same ac source.
   If the EUT power cord is long enough to be bundled, the bundle should be secured with masking tape or any other nonconducting material that will not affect the measurements. Power cords of non-EUT equipment do not require bundling. Drape ac power cords of non-EUT equipment over the rear edge of the table and route them down onto the floor of the conducted test site to the second LISN. Power cords of floor-standing accessory equipment may be routed in any convenient fashion atop the ground plane or insulating material specified in 6.2.2. Power cords of peripheral equipment should not be draped over the top of an LISN. Refer to Pigs 9(a) or 9(b) for typical test setups.

H.2 AC Powerline Conducted Emissions Testing

1) Check the calibration of the measuring instrument using either an internal calibrator or a known signal level from an external signal generator.
2) A spectrum analyzer or other instrument providing a spectral display is recommended for preliminary ac powerline conducted measurements. Connect the measuring instrument to the RF port of a section of the LISN supplying current to one of the conductors to the EUT using a suitable length of coaxial cable. Terminate all other RF ports of the LISN(s) in 50 Ω resistive. Set the 6 dB bandwidth of the measuring instrument to not less than 10 kHz and the detector function to the peak mode. Set the controls on the measuring instrument to enable viewing the entire frequency range for which limits are specified.
3) Activate the EUT and the measuring instrument to meet the requirements of 6.1.9.
4) With the EUT operating on any convenient output channel or tuned to any one convenient frequency specified in 12.1.1, exercise the EUT as specified in step 3 of the ac powerline conducted setup. Accessory equipment connected to the EUT shall be exercised individually.

NOTE — Some EUTs, especially receivers with synthesized tuners and remote controls, may have moro oscillators than the one used for frequency conversion in the RF input circuitry. These may cause emissions not normally found in simpler types of EUTs.

5) Use the procedure in 7.2.3, while applying the appropriate modulating signal to the EUT, to determine the configuration of the EUT system that produces the emission with the highest amplitude relative to the limit. The EUT may be turned off and on to determine which emissions emanate from it.

   NOTE — In the case of a TV interface device capable of operation with external video input, make one set of tests with the VITS signal at 1 V, and a second with it at 5 V.

6) Repeat step 5 with the measuring instrument connected to the RF port of the other LISN section supplying the EUT with ac power.

   NOTE — Measurements are to be made only on emanations available at the RF ports of the LISNs connected te the EUT.

7) Select the EUT configuration and mode of operation that produced the highest emission relative to the limit for final ac powerline conducted emissions measurements. If the EUT is moved to a final ac powerline conducted test site from a preliminary conducted test site, remaximize the highest emission according to 7.2.4. Set the bandwidth and the detector function of the instrument as specified by the procuring or regulatory agency. Follow the procedure in 12.1.3.2 or 12.2.3.2 as appropriate, to measure the final ac powerline conducted emissions from the EUT.
8) Repeat step 7 with the measuring equipment connected to the RF port of the other LISN section supplying the EUT with ac power.
9) Record the EUT configuration, mode of operation, and interconnect cable or wire positions used for final ac powerline conducted emissions tests. This can be done either diagrams or photographs.
10) Prepare the final test report data in accordance with Section 10.

H.3 Radiated Test Setup

1) Preliminary radiated measurements should generally follow procedures in Sections 8 and 12. The measuring instruments shall conform to the requirements in Section 4.
2) The EUT shall be placed on a turntable specified in 5.4.4 and configured as in steps 2, 3, and 4 of the H1 ac powerline conducted test setup. All resistive terminations in place in steps 2, 3, and 4 of H1 shall remain in place during radiated emissions measurements.
3) If operated from ac power, connect the power cord of the EUT (and of any accessory equipment) to the ac power source located on the turntable. If battery operated, begin the tests with a new or a fully charged battery installed in the EUT.

   AC power cords of the EUT and accessories do not require bundling. Drape all ac power cords of equipment tested on a tabletop over the rear edge of the table and route them down onto the turntable surface to the ac outlet. AC power cords of floor-standing equipment may be routed in any convenient fashion Refer to Figs 9(c) and 9(d).

   If the EUT is provided only with an adjustable permanently attached antenna, it shall be tested with this antenna extended to its maximum length. If the EUT is provided with terminals for connection of an external antenna, connect the antenna normally used with the EUT to these terminals, and position it in a typical location or orientation.

   NOTE — In the case of a receiver (or tuner) that is tested for radiated emissions measurements with a resistive termination rather than an antenna connected to the antenna input terminals, measurement of the RF power available at the antenna input terminals also is required. See HS.

4) If the EUT is a receiver, it shall be supplied with the conditioning or stabilizing signal specified in 12.1.1.1 or 12.1.1.2, as applicable, by radiation or conduction. The conditioning signal may be applied to the EUT by radiation or conduction on any frequency within the range of the EUT.

   If the EUT is a TV interface device, it shall be operated with typical signals applied as specified in 12.2.1.1, 12.2.1.2, 12.2.1.3, or 12.2.1.4, whichever is applicable.

H.4 Radiated Emissions Testing

1) Check the calibration of the measuring instrument using either an internal calibrator or a known signal level from an external signal generator.

2) A spectrum analyzer or other instrument providing a spectral display is recommended for preliminary radiated measurements. The frequency range may be scanned in segments or in its entirety, depending upon the rated frequency range of the measurement antenna (see NOTE under step 5 below). Set the 6 dB bandwidth of the measuring instrument to 100 kHz and the detector function to the peak mode. Set the display on the measuring instrument to enable viewing of emissions between 30 MHz and 230 MHz by setting the scan width control on the analyzer to 20 MHz per division. Adjust the sweep speed control so the analyzer display is calibrated. Video filtering is not used during these tests.

   NOTE — If ambient radio or TV signals are of such magnitude or spacing that emissions from the EUT may be hidden, the scan width control can be set to 10 MHz per division or less to identify EUT emissions. Use of bandwidth less than 100 kHz may be helpful.

3) Activate the EUT and the measuring instrument to meet the requirements of 6.1.9.

   If the EUT is a receiver that tunes over a range of frequencies, set it to one of the number of frequencies specified in 12.1.1. If the EUT is a TV interface device, set it to one of the output channels.

4) Exercise the EUT as specified in 12.1.1 or 12.2.1 as appropriate. Accessories connected to the EUT shall be exercised independently.

   NOTE — Some EUTs, especially receivers with synthesized tuners and remote controls, may have more oscillators than the one used for frequency conversion in the RF input circuitry. These may cause emissions not normally found in simpler types of EUTs.

5) Use a procedure such as that contained in Appendix D in conjunction with the procedure in 12.1.4.1 or 12.2.4.1, as appropriate, to maximize emissions from the EUT and note the EUT attitude, configuration, operating mode, operating frequency, and interconnect cable or wire positions that produce the highest emission relative to the limit. In addition, preliminary radiated emissions testing of hand-held or body-worn devices shall include rotation of the EUT through three orthogonal axes to determine the attitude that produces the highest emission relative to the limit.

   NOTE — A broadband antenna is recommended for preliminary scanning of radiated emissions. It will be necessary to change to other measurement antennas during this process to stay within the frequency range of the measurement antenna.

6) Tune the spectrum analyzer to the next segment of the frequency spectrum to be scanned and repeat steps 3 through 6 until the frequency range of interest has been investigated.

7) Where the procuring or regulatory agency require radiated measurements with the EUT operating on more than one output channel or tuned to more than one frequency, repeat steps 3 through 6 for each additional output channel or frequency.

8) Select the EUT attitude, configuration, operating mode, output channel or operating frequency and interconnect cable or wire positions from step 5 that produced the highest emission relative to the limit to use for final radiated measurements. The final radiated emissions test facility shall conform to the requirements of 5.4–5.4.2.1. Set the measurement and the detector function as specified by the procuring or regulatory agency.

9) It is recommended that the highest emission relative to the limit be remaximized according to 8.3.1.2 before performing final measurements, even if the EUT is not moved from a preliminary to a final radiated test site because slight variations in cable or wire positions can cause large variations in signal amplitude. Only slight variation in cable movements should be needed to remaximize the highest emission again.

   NOTE — The same measurement antenna and distance should be used for remaximizing the highest emission relative to the limit at the final radiated emissions test site.

10) Place the measurement antenna specified in 4.1.5 at the distance from the EUT specified in the appropriate regulations.

11) Follow the procedure in 8.3.1.2 and 12.1.4.2 or 12.2.4.2, as appropriate, to measure final radiated emissions from the EUT.

   NOTES:

   1 — It will be necessary to change to other measurement antennas during this process to stay within the frequency range of the measurement antenna.

   2 — In the case of an EUT that radiates pulsed emissions (e.g., a superregenerative receiver), depending upon the pulse length, repetition rate, and duty cycle of the emission, “desensitization” may cause the indications of the measuring equipment may be much less than the true peak value of the emission. Refer to the measuring instrument instruction manual or an application note from the manufacturer of the equipment for the appropriate correction factor to be applied to the indicated value to obtain an accurate value for the test report.

   If regulations do not require radiated measurements above 1 GHz, proceed to step 14.

If radiated measurements above 1 GHz are required, an instrument capable of measuring both peak and average detector function signals shall be used. Set the bandwidth of this instrument to 1 MHz and the detector function to the peak mode. Measure final radiated emissions above 1 GHz from the EUT by following the procedures in 8.2.4 and 12.1.4.2 or 12.2.4.2 as appropriate.

12) If all of the emission levels above 1 GHz as measured with the peak detector function comply with the average limit specified by the appropriate regulations, proceed to step 14. If any of these emission levels exceed the average limits but comply with the peak limits, proceed to step 13.
13) Set the detector function of the measuring instrument to the average mode and, using the procedures described in 8.2.4 and 12.1.4.2 or 12.2.4.2 as appropriate, remeasure only those emissions from step 12 that complied with the peak limits but exceeded the average limits.

    NOTE — As indicated in NOTE 2 under step 11, the measuring instrument may not be capable of indicating a true average value of pulsed emissions. The average value can in such cases be calculated from the peak value, taking into account the ratio between the pulse duration (at the 50% amplitude level) and the length of time between pulses.
14) Record the EUT attitude, configuration, operating mode, operating frequency, and cable or wire positions used for final radiated emissions measurements. This can be done with either diagrams or photographs.
15) Prepare the final test report data in accordance with Section 10.

H.5 Antenna-Conducted Power Measurements for Receivers

NOTE — These measurements are required only for receivers that were tested for radiated emissions with a terminating resistor instead of an antenna connected to the antenna input erminals.

1) Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external signal generator.
2) The frequency range may be scanned in segments or in its entirety depending upon the measuring instrument. Set the 6 dB bandwidth of the measuring instrument to 100 kHz and the detector function to the peak mode. Set the display on the measuring instrument to enable viewing of emissions between 30 MHz and 230 MHz by setting the scan width control on the analyzer to 20 MHz per division. Adjust the sweep speed control so the analyzer display is calibrated. Video filtering is not used during these tests.

    NOTE — Where the procuring or regulatory agency specifies limits using CISPR quasi.peak detection, if the peak measured value meets the CISPR quasi-peak limit, it is unnecessary to perform a quasi-peak measurement.
3) Position the EUT as specified in 6.2. Connect the measuring equipment to the antenna input terminals of the EUT, using a balun or other impedance-matching device if necessary.

    NOTE — If the EUT is part of a transceiver, it is advisable to disable the switch that enables the transmitter to protect the measuring instrument.
4) Activate the EUT and the measuring instrument to meet the requirements of 6.1.9. Tune the EUT to one of the number of frequencies specified in 12.1.1 and exercise it as specified in 12.1.1.1. Accessories connected to the EUT shall be exercised independently.

    NOTE — Some EUTs, especially receivers with synthesized tuners and remote controls, may have more oscillators than the one used for frequency conversion in the RF input circuitry. These may cause emissions not normally found in simpler types of EUTs.
5) While applying the appropriate modulating signals individually, scan the specified range of measurements and record the level of the six highest emissions relative to the limit below 1GHz.

    NOTE — A peak voltage of 316 μV or less into 50 Ω complies with the regulations for receivers operating in the range of 30 to 960 MHz.

    If all observed peak values are less than the limit for the CISPR quasi-peak value of antenna-conducted emissions stated in the regulations, proceed to step 7. If any of these emissions exceed the CISPR quasi-peak limit, proceed to step 6.
6) Set the bandwidth and the detector function as specified by the procuring or regulatory agency and remeasure only those emissions measured in step 5 that in the peak detector mode exceeded the CISPR quasi-peak limit.
7) If regulations do not require antenna-conducted power measurements above 1 GHz, proceed to step 10.

    If antenna-conducted power measurements above 1 GHz are required, an instrument capable of measuring both peak and average detector function signals shall be used. Set the bandwidth of this instrument to 1 MHz and the detector function to the peak mode. Measure the emissions above 1 GHz from the EUT by following the above procedure.

8) If all of the emission levels above 1 GHz as measured with the peak detector function comply with the average limit specified by the appropriate regulations, proceed to step 10. If any of these emission levels exceed the average limit but comply with the peak limit, proceed to step 9.
9) Set the detector function of the measuring instrument to the average mode, and remeasure only those emissions measured in step 8 that in the peak detector mode exceeded the average value limits.
10) Where 12.1.1 requires measurement with the EUT tuned to more than one frequency for test, repeat steps 4 through 9 for each additional output channel or frequency.
11) Prepare the final test report in accordance with Section 10.

H.6 TV Interface Device Output and Spurious Level Measurements

NOTE — Section H6 applies only to devices where these measurements are required by the procuring or regulatory agency.

1) Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external signal generator.
2) A spectrum analyzer or other instrument providing a spectral display is recommended for preliminary measurements. Video filtering is not used during these tests.
   For measurements in the range 30 to 1000 MHz, set the bandwidth of the measuring instrument to 100 kHz and the detector function to the peak mode. The frequency range may be scanned in segments or in its entirety, adjusting the sweep speed control so that the display is calibrated.
   It is recommended that RG-214 for 50 W systems other appropriate double-shielded coaxial cable be used for all connections to measuring equipment, keeping lengths as short as practicable.
3) Configure the EUT as specified in 6.2 and 12.2.2. Remove the termination connected to the end of the EUT output cable and connect the output cable to the measuring instrument, using an impedance-matching device or balun, as appropriate.
4) Energize the EUT and set it to one of its output channels.

5a) If the EUT operates only from internal video signals, it shall be tested with these in normal operation. A VCR shall be tested in the record and play modes using a standard TV signal as the modulating signal. Measure the signal level at the visual and aural carrier frequencies. Also measure any emissions in the range from 30 MHz to 4.6 MHz below the visual carrier frequency, and any emissions in the range from 7.4 MHz above the visual carrier frequency to 1 GHz.

5b) If the EUT also operates from externally generated video signal(s), it shall be tested with modulation as follows: (1) with the internal signals described in 5a, (2) external VITS signal at 1 V peak to peak, and (3) external VITS signal at 5 V peak to peak. Measure the signal level at the visual and aural carrier frequencies. Also measure any emissions in the range from 30 MHz to 4.6 MHz below the visual carrier frequency, and any emissions in the range from 7.4 MHz above the visual carrier frequency to 1 GHz.

5c) If the EUT is a CSTD, it shall be supplied with input RF signal from a typical broadband cable TV source set at a level of 25 dB(mV). Measure the signal level at the visual and aural carrier frequencies of the output channel. Also measure any emissions in the range from 30 MHz to 4.6 MHz below the visual carrier frequency, and any emissions in the range from 7.4 MHz above the visual carrier frequency to 1 GHz.

6) Repeat steps 5a, 5b or 5c, as appropriate, for any other available output channel(s) on the EUT.
7) Prepare the final test report in accordance with Section 10.

H.7 Cable TV Antenna Transfer Switch Measurements

NOTE — Section H7 applies only to devices where these measurements are required by the procuring or regulatory agency.

When required by the procuring or regulatory agency, the following procedure may be used to determine the isolation of a cable TV antenna transfer switch that is either built in to a device or is a stand-alone, external switch.

1) Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external signal generator.

2) A measuring instrument with a peak detector function shall be used. A standard signal generator with calibrated output shall be used to provide the test signal.
   Depending upon the noise figure of the measuring instrument, a low-noise, broadband amplifier may be needed to perform these measurements.
3) Position the device containing the isolation switch as described in 6.2 or place the isolation switch on a nonconducting table 80 cm in height Connect a suitable resistive termination to the output terminals of the device or switch.
4) Connect a signal generator to the port that is used for cable TV input to the device or switch using any convenient length of connecting cable with an impedance-matching device as required to match the rated input impedance of the terminal. It is recommended that a pad with at least 6 dB loss be placed as near as possible to the terminal to minimize any residual mismatch effects.
   NOTE — Type RG-214 for 50 Ω systems or other appropriate double-shielded coaxial cable should be used for all connections, and they should be as short as practicable.
5) Connect the measuring instrument to an antenna terminal of the device or switch, with an impedance-matching device if required to match the rated input impedance of the terminal. It is recommended that a pad with at least 6 dB of loss be placed as near as possible to the terminal to minimize any residual mismatch effects. If the device or switch has more than two antenna input terminals, connect a suitable termination to any unused ones.
6) With an unmodulated input signal of 0 dBm applied at 54 MHz from the signal generator to the device or switch cable TV input terminal, measure the signal at 54 MHz available at the terminal connected to the measuring instrument, sequentially using all positions of the antenna selector switch. If the device is electrically operated, also measure the signal with power off. Record the signal level for each switch position, including the value observed with the device power off (if applicable).
7) Disconnect the signal generator and measuring instrument from the device or switch, and connect the signal generator to the measuring instrument using the cables and impedance-matching devices (and pads, if used)formerly connected to the device or antenna transfer switch.
   NOTE — In the event that the original matching devices are not appropriate for this connection (e.g., if the device or antenna transfer switch have different input and output impedances), change the impedance-matching devices as necessary for proper impedance match.
   If the device or switch has input terminals for nominal 300 Ω antenna twin-lead and the output terminals are coaxial, it is desirable to delete, the baluns that were required for proper connection to the measuring instrument in steps 6 or 7.
8) With the measuring instrument and signal generator set to 54 MHz as above, reduce the signal generator output to obtain the same levels as previously recorded in steps 6 and 7 for each position of the antenna transfer switch, including with power off (if applicable). The difference in the signal generator output level in this measurement as compared to that applied in step 7 is the attenuation of the switch at 54 MHz. Record the difference in dB.
   NOTE — If impedance-matching devices or baluns were changed in the transition from steps 6 and 7 to steps 8 and 9, the apparent attenuation level measured in steps 8 and 9 shall be corrected to account for any differences in attenuation due to the changes of these devices.
9) Repeat steps 6 through 8 with applied signal at 150, 200, 250, 300, 350, 400, 450, 500, and 550 MHz.
10) If the device or switch has more than two input terminals, repeat steps 4 through 9 with the signal generator connected to the third, fourth, etc., terminals.
11) Prepare the final test report in accordance with Section 10.

H.8 TV Interface Device Antenna Transfer Switch Measurements

NOTE — Section H8 applies only to devices where these measurements are required by the procuring or regulatory agency.

1) Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external signal generator.
2) A spectrum analyzer or other instrument providing a spectral display is recommended for these measurements. Video filtering is not used during these tests.

Set the bandwidth of the measuring instrument to 100 kHz and the detector function to the peak mode.

Type RG-233, RG-55, or other double-shielded coaxial cable should be used, with connections kept as short as practical.

Depending upon the noise figure of the measuring instrument, a low-noise broadband amplifier may be needed to enable these measurements.

H.8.1 Switches with Coaxial Input Ports

1) Position the device as specified in 6.2. Place an external antenna transfer switch on a table 80 cm in height above ground. The output port of a TV interface device shall be connected to either (1) the cable provided with the device or (2) a cable of typical length. This output cable shall be connected to either a terminating resistor of the proper impedance or the antenna transfer switch provided with the device. The output terminal of the antenna transfer switch shall be terminated in the proper impedance.
   NOTE — If the device has a coaxial output port, connect a resistive termination of the proper impedance directly to it.
   Keep the output cable and antenna transfer switch at least 75 cm away from any conducting object by placing it on a table.

2a) If the device operates only from internal video signals (e.g., a TV game or VCR), it shall be tested with these in normal operation (using a video tape with a typical TV signal recorded on it for the signal source, if necessary).

2b) If the device also operates from externally generated video signals, it shall be tested with modulation as follows: (1) with the internal signals, (2) external VITS signal at 1 V peak to peak, and (3) external VITS signal at 5 V peak to peak.

2c) If the device is a CSTD, adjust it for operation from cable TV input. Two cable TV input signal levels shall be supplied alternately, first, 0 dB(mV), and then 25 dB(mV).

3) Using as short a length of coaxial cable as possible, connect the antenna input port to the measuring instrument, with an impedance-matching device if necessary. If the device or switch has more than one antenna input port, terminate any unused ones with a suitable resistive termination.
   Set the device to one of the channels on which it operates, energize it, and adjust it for operation from internally generated signals.

4) Measure the frequency and level of the video carrier on which the TV interface device is operating for each position of the antenna transfer switch. If the TV interface device and the antenna transfer switch operate from ac power, repeat this measurement with the ac power turned off. Change the TV interface device output channel and repeat the above two measurements for each output channel available on the TV interface device.
   NOTE — Corrections should be applied to account for differences of losses in matching devices and cables.

5) Repeat steps 2 through 4 for any other pair of antenna input ports provided on the device or switch.

6) Prepare the final test report in accordance with Section 10.

H.8.2 Switches with Balanced Line Connectors

1) Position the device as specified in 6.2. Place an external antenna transfer switch on a table 80 cm in height above ground. The output port of a TV interface device shall be connected to either (1) the cable provided with the device or (2) a cable of typical length. This output cable shall be connected to either a terminating resistor of the proper impedance or the antenna transfer switch provided with the device. The output terminal of the antenna transfer switch shall be terminated in the proper impedance.
   Keep the output cable and antenna transfer switch at least 75 cm away from any conducting object by placing it on a table.

2a) If the device operates only from internal video signals (e.g., a TV game or VCR), it shall be tested with these in normal operation (using a video tape with a typical TV signal recorded on it for the signal source, if necessary).

2b) If the device also operates from externally-generated video signals, it shall be tested with modulation as follows: (l) with the internal signals, (2) external VITS signal at 1 V peak to peak, and (3) external VITS signal at 5 V peak to peak.

2c) If the device is a CSTD, adjust it for operation from cable input and supply it with a cable TV signal at a level of 25 dB(mV).

3) Set the device to one of the available output channels. Connect a length of 300 Ω twinlead 3/4 of a wavelength long at the device output channel frequency to the input terminals on the device or switch and connect the measuring instrument to the other end of this line, using a balun for impedance matching. Support this lead in a horizontal straight line from the device or switch to the measuring instrument, keeping it at least 75 cm from any other conducting objects.
   If the device or switch has more than one set of antenna input terminals, terminate the others.
   Energize the device and adjust it for operation from internally generated signals.
4) Measure the frequency and level of the video carrier on which the TV interface device is operating for each position of the antenna transfer switch. If the TV interface device and the antenna transfer switch operate from ac power, repeat this measurement with the ac power turned off and externally generated signals applied as specified above. Change the TV interface device output channel and repeat the above two measurements for each output channel available on the TV interface device.
   NOTE — Corrections should be applied to account for differences of losses in matching devices and cables.
5) Next, reduce the length of the twin-lead in two steps of 1/3 of the original length, and repeat step 4 (this results in one set of measurements each at 3/4, 1/2, and 1/4 wavelength).
6) Repeat steps 2 through 5 for any other pair of antenna input ports provided on the device or switch, with the device both energized and de-energized.
7) Repeat steps 3 through 6 for each available output channel on the device.
8) Prepare the final test report in accordance with Section 10.

Annex I Step-by-Step Guidance for Testing Intentional Radiators

(Informative)

The following procedure may be used as a guide for determining compliance of intentional radiators operating on frequencies above 30 MHz that can be tested on an open field test site with certain regulatory requirements. The section numbers refer to sections or subsections in this standard.

I.1 AC Powerline Conducted Setup

NOTE — Section Il applies only to EUTs that operate en power from public utility powerlines.

1) The ac powerline conducted test facility shall conform to the requirements of 5.25.2.3 and 7.2-7.2.2. The measuring instruments, including the LISN, shall conform to the requirements in Section 4.
2) The EUT shall be configured in accordance with Sections 6-6.2.3.3 and 13-13.1.2. If the EUT uses a detachable antenna, ac powerline conducted measurements shall be made with a suitable dummy load connected to the EUT antenna output terminals; otherwise, these tests shall be made with the antenna connected and, if adjustable, fully extended.
3) Use the type and length of interface cables specified in 6.1.4 and connect them to the interface ports on the EUT in accordance with 6.1.3. Interface cables shall be individually bundled as described in 6.1.4. The bundle should be secured with masking tape or any other nonconducting material that will not affect the measurements.
4) Connect the EUT power cord to one LISN and connect the peripheral or support equipment power cords to a separate LISN as described in 7.2.1. AC power for all LISNs is to be obtained from the same ac source.
   If the EUT power cord is long enough to be bundled, the bundle should be secured with masking tape or any other nonconducting material that will not affect the measurements. Power cords of non-EUT equipment do not require bundling. Drape ac power cords of non-EUT equipment over the rear edge of the table and route them down onto the floor of the conducted test site to the second LISN. Power cords of floor-standing accessory equipment may be routed in any convenient fashion atop the ground plane or insulating material specified in 6.2.2. Power cords of peripheral equipment should not be draped over the top of an LISN. Refer to Figs 9(a) or 9(b) for typical test setups.
5) The EUT shall be supplied with the appropriate modulation specified in 13.1.1.1. If the EUT transmits only pulsed modulation and has coding switches, these shall be set to the position that produces the maximum duty cycle during measurements.

I.2 AC Powerline Conducted Emissions Testing

1) Check the calibration of the measuring instrument using either an internal calibrator or a known signal level from an external signal generator.
2) A spectrum analyzer or other instrument providing a spectral display is recommended for preliminary ac powerline conducted measurements. Connect the measuring instrument to the RF port of a section of the LISN supplying current to the EUT using a suitable length of coaxial cable. Terminate all other RF ports of the LISN(s) in 50 Ω resistive. Set the 6 dB bandwidth of the measuring instrument to not less than 10 kHz and the detector function to the peak mode. Set the controls on the measuring instrument to enable viewing the entire frequency range for which limits are specified.
3) Activate the EUT and the measuring instrument to meet the requirements of 6.1.9. The EUT should be set to transmit on any one convenient frequency in its rated range.
4) Exercise the EUT in all modes of operation as specified in 13.1.1.1. Accessory equipment connected to the EUT shall be exercised individuality.
5) Use the procedure in 7.2.3, while applying the appropriate modulating signal to the EUT, to determine the configuration of the EUT system that produces the emission with the highest amplitude relative to the limit. The EUT may be turned off and on to determine which emissions emanate from it.

6) Repeat step 5 with the measuring instrument connected to the RF port of the other LISN section supplying the EUT with ac power.

   NOTE — Measurements are to be made only on emanations available at the RF ports of the LISNs connected to the EUT.

7) Select the EUT configuration and mode of operation that produced the highest emission relative to the limit for final ac powerline conducted emissions measurements. If the EUT is moved to a final ac powerline conducted test site from a preliminary Conducted test site, be sure to remaximize the highest emission according to 7.2.4. Set the bandwidth and the detector function of the instrument as specified by the procuring or regulatory agency. Follow the procedure in 13.1.3.2 to measure the final ac powerline conducted emissions from the EUT.
8) Repeat step 7 with the measuring equipment connected to the RF port of the other LISN section supplying the EUT with ac power.
9) Record the EUT configuration, mode of operation, and interconnect cable or wire positions used for final ac powerline conducted emissions tests. This can be done with either diagrams or photographs.
10) Prepare the final test report data in accordance with Section 10.

I.3 Radiated Test Setup

1) Preliminary radiated measurements should generally follow procedures in Sections 8 and 13. The measuring instruments shall conform to the requirements in Section 4.
2) The EUT shall be positioned on a turntable as specified in 5.4.4 and configured as in steps 2 and 3 of the 11 ac powerline conducted test setup.
3) If operated from ac power, connect the power cord of the EUT (and of any accessory equipment) to the ac power source located on the turntable. If battery operated, begin the tests with a new or a fully charged battery installed in the EUT.

   The ac power cords of the EUT and accessories do not require bundling. Drape all ac power cords of equipment tested on a tabletop over the rear edge of the table and route them down onto the turntable surface to the ac outlet. AC power cords of floor-standing equipment may be routed in any convenient fashion. Refer to Figs 9(c) and 9(d).
4) If the EUT is provided only with an adjustable permanently attached antenna, it shall be tested with this antenna extended to its maximum length. If the EUT is provided with terminals for connection of an external antenna, connect the antenna normally used with the EUT to these terminals, and position it in a typical location or orientation.
5) The EUT shall be supplied with modulation as specified in 13.1.1.1. If the EUT transmits only pulsed modulation and has coding switches, these shall be set to the position that produces the maximum duty cycle during measurements.

I.4 Radiated Emissions Testing

1) Check the calibration of the measuring instrument using either an internal calibrator or a known signal level from an external signal generator.
2) A spectrum analyzer or other instrument providing a spectral display is recommended for preliminary radiated measurements. The frequency range may be scanned in segments or in its entirety depending upon the rated frequency range of the measurement antenna (see NOTE under step 5 below). Set the 6 dB bandwidth of the measuring instrument to 100 kHz and the detector function to the peak mode. Set the display on the measuring instrument to enable viewing of emissions between 30 MHz and 230 MHz by setting the scan width control on the analyzer to 20 MHz per division. Adjust the sweep speed control so the analyzer display is calibrated. Video filtering is not used during these tests.

   NOTES:

   1 — If ambient radio or TV signals are of such magnitude or spacing that emissions from the EUT may be hidden, the scan width control can be set to 10 MHz per division or less to identify EUT emissions. Use of a bandwidth less than 100 kHz may be helpful.

2 — The bandwidth of the measuring instrument must be wider than the pulse repetition frequency of the transmitted signal in order to measure its maximum peak level. See [18] for guidelines on selecting bandwidth and determining pulse desensitization factors, as necessary.

3) Activate the EUT and the measuring instrument to meet the requirements of 6.1.9. If the EUT operates over a range of frequencies, set it to one of the number of frequencies specified in 13.1.1.

   NOTE — These preliminary tests shall be run with the EUT powered in turn from both ac and dc (battery) power, if the device has these capabilities, to determine which power source produces the highest emission relative to the limit.

4) Exercise the EUT as specified in 13.1.1.1. Accessories connected to the EUT shall be exercised independently.

5) Use a procedure such as that contained in Appendix D in conjunction with the procedure in 13.1.4.1 to maximize emissions from the EUT and note the EUT attitude, configuration, operating mode, and interconnect cable or wire positions that produce the highest emission relative to the limit. In addition, preliminary radiated emissions testing of hand-held or body-worn devices shall include rotation of the EUT through three orthogonal axes to determine the attitude that produces the highest emission relative to the limit.

   NOTE — A broadband antenna is recommended for preliminary scanning of radiated emissions. It will be necessary to change to other measurement antennas during this process to cover the complete frequency range of the test.

6) Tune the spectrum analyzer to the next segment of the frequency spectrum to be scanned and repeat steps 3 through 5 until the frequency range of interest has been investigated.

   Where the procuring or regulatory agency require radiated measurements with the EUT tuned to more than one frequency, repeat steps 3 through 5 for each additional frequency.

7) Select the EUT attitude, configuration, operating mode, and interconnect cable or wire positions from step 5 that produced the highest emission relative to the limit to use for final radiated measurements. The final radiated emissions test facility shall conform to the requirements of 5.4-5.4.2.1. Set the bandwidth and the detector function as specified by the procuring or regulatory agency.

8) It is recommended that the highest emission relative to the limit be remaximized per 8.3.1.2 before performing final measurements, even if the EUT is not moved from a preliminary to a final radiated test site, because slight variations in cable or wire positions can cause large variations in signal amplitude. Only slight variation in cable movements should be needed to remaximize the highest emission again.

   NOTE — The same measurement antenna and distance should be used for remaximizing the highest emission relative to the limit at the final radiated emissions test site.

9) Place the measurement antenna specified in 4.1.5 the distance from the EUT specified in the appropriate regulations.

10) Follow the procedure in 8.3.1.2 and 13.1.4.2 to measure final radiated emissions from the EUT on the number of frequencies specified in 13.1.1.

   NOTE — It will be necessary to change to other measurement antennas during this process to cover the complete frequency range of the test.

   When average detector function limits are specified for a pulse-modulated transmitter, the average level of emissions may be found by measuring the peak level of the emissions and correcting them with the duty cycle as follows: (1) Turn on the transmitter and set it to transmit the pulse train continuously. (2) Tune a spectrum analyzer to the transmitter carrier frequency and set the spectrum analyzer resolution bandwidth wide enough to encompass all significant spectral components. The video bandwidth should be at least as wide as the resolution bandwidth. (3) Set the spectrum analyzer vertical scale (amplitude) to the linear mode and the analyzer frequency scan to 0 Hz. If necessary, move the receiving antenna closer to the device to obtain a convenient signal. level. (4) Connect a storage oscilloscope to the video output of the spectrum analyzer that is used to demodulate and detect the pulse train. (Although the pulse train may be viewed by using just a spectrum analyzer with a scan width of 0 Hz, the use of an oscilloscope facilitates viewing the pulses and allows a more accurate measurement of their width.) (5) Adjust the oscilloscope settings to observe the pulse train and determine the number and width of the pulses, as well as the period of the train. (6) Adjust the transmitter controls, jumper wires, or software to maximize the transmitted duty cycle. (7) Measure the pulse width by determining the time difference between the two half-voltage points on the pulse. (8) When the pulse train is less than 100 ms, including blanking intervals, calculate the duty cycle by averaging the sum of the pulse widths over one complete pulse train. Alternatively, or when the pulse train exceeds 100 ms, calculate the duty cycle by averaging the sum of the pulse widths over the 100 ms width with the highest average value. [The duty cycle is the value of the sum of the pulse widths in one period (or 100 ms), divided by the length of the period (or 100 ms)]. (9) Multiply the peak-detector field strength (expressed in uV/m) of an emission from a transmitter using pulsed modulation by the duty cycle just measured to determine the average detector field strength of that emission for comparison to the average detector limit.

If regulations do not require radiated measurements above 1 GHz, proceed to step 13. If radiated measurements above 1 GHz are required, an instrument capable of measuring both peak and average detector function signals shall be used. Set the bandwidth of this instrument to 1 MHz and the detector function to the peak mode. Measure final radiated emissions above 1 GHz from the EUT by following the procedures in 8.2.4 and 13.1.4.2.

11) If all of the emission levels above 1 GHz as measured with the peak detector function comply with the average limit specified by the appropriate regulations, proceed to step 13. If any of these emission levels exceed the average limit but comply with the peak limit, proceed to step 12.
12) Set the detector function of the measuring instrument to the average mode, using the procedures described in 8.2.4 and 13.1.4.2, and remeasure only those emissions from step 11 that complied with the peak limits but exceeded the average limits.
13) Record the EUT attitude, configuration, operating mode, and cable or wire positions used for final radiated emissions measurements. This can be done with either diagrams or photographs.
14) Prepare the final test report data in accordance with Section 10.

Where radiated measurements are required on an EUT on more than one operating frequency, the report shall list the field strength measured at the fundamental frequency, the field strength of the three highest harmonic or spurious emissions relative to the limit, and the field strength of the three highest restricted band emissions relative to the limit and the frequencies on which these were observed), for each operating frequency measured.

NOTE — For the purposes of this document, spurious emissions shall include out-of-band emissions typically associated with or generated by the modulating signal.

I.5 Frequency Measurements

NOTE — Section 15 applies only to devices where these measurements are required by the procuring or regulatory agency.

I.5.1 Measurements of Operating Frequency

1) Operating frequency measurements may be made at ambient room temperature if it is within the range of +15 ˚to +25 ˚C; otherwise, an environmental temperature test chamber set for a temperature of +20 ˚C shall be used. An antenna should be connected to the antenna output connector of the EUT if possible. Use of a dummy load could affect the output frequency of the EUT. If the EUT is equipped with or uses an adjustable-length antenna, it should be fully extended.
2) Supply the EUT with nominal ac voltage or install a new or fully charged battery in the EUT. Turn the EUT on and couple its output to a frequency counter or other frequency-measuring device of sufficient accuracy, considering the frequency tolerance with which the EUT must comply.

   NOTE — An antenna connected to the measuring instrument with a suitable length of coaxial cable may be placed near the EUT (e.g., 15 cm away) for this purpose.

   Tune the EUT to any one of the number of frequencies specified in 13.1.1. Adjust the location of the measurement antenna and the controls on the measuring instrument to obtain a suitable signal level (i.e., a level that will not overload the measuring instrument, but is strong enough to allow measurement of the operating or fundamental frequency of the EUT). Turn the EUT on and measure the EUT operating frequency at start-up, and two, five, and ten minutes after startup. Four measurements in total are made.
3) Turn the EUT off and place it inside an environmental chamber, if appropriate, or position it as specified in 6.2. Allow the chamber to stabilize at +20 ˚C (approximately 30 rain) before proceeding.
4) If 13.1.1 requires measurements on only one operating frequency, proceed to step 5; otherwise, turn the EUT off and allow sufficient time for it to stabilize at ambient temperature, then repeat step 3 with the EUT set successively to each of the additional operating frequencies specified in 13.1.1.
5) Prepare the final test report in accordance with Section 10.

I.5.2 Measurements of Frequency Stability vs. Temperature

1) Place the de-energized EUT in an environmental temperature test chamber. Supply the EUT with nominal ac voltage or install a new or fully charged battery in the EUT. An antenna should be connected to the antenna output connector of the EUT if possible. Use of a dummy load could affect the output frequency of the EUT. If the EUT is equipped with or uses an adjustable-length antenna, it should be fully extended.
2) Turn the EUT on and couple its output to a frequency counter or other frequency-measuring device of sufficient accuracy, considering the frequency tolerance with which the EUT must comply.

   NOTE — An antenna connected to the measuring instrument with a suitable length of coaxial cable may be placed near the EUT (e.g., 15 cm away) for this purpose.

   Tune the EUT to one of the number of frequencies specified in 13.1.1. Adjust the location of the measurement antenna and the controls on the measuring instrument to obtain a suitable signal level (i.e., a level that will not overload the measuring instrument, but is strong enough to allow measurement of the operating or fundamental frequency of the EUT).
3) Turn the EUT off and place it inside an environmental chamber set to the highest temperature specified by the procuring or regulatory agency. For devices that are normally operated continuously, the EUT may be energized while inside the test chamber. For devices that have oscillator heaters, energize only the heater circuit while the EUT is inside the chamber.
4) Allow sufficient time (approximately 30 min) for the temperature of the chamber to stabilize. While maintaining a constant temperature inside the environmental chamber, turn the EUT on and measure the EUT operating frequency at startup, and two, five, and ten minutes after startup. Four measurements in total are made.
5) If 13.1.1 requires measurements on only one operating frequency, proceed to step 6; otherwise, successively tune the EUT to each of the additional operating frequencies specified in 13.1.1 and repeat step 4.
6) Repeat steps 4 and 5 with the temperature chamber set to the lowest temperature specified by the procuring or regulatory agency. Be sure to allow the environmental chamber temperature to stabilize before performing these measurements.
7) Prepare the final test report in accordance with Section 10.

I.5.3 Frequency Stability vs. Input Voltage

1) This test may be made at ambient room temperature if it is within the range +15 ° to +25 °C; otherwise, an environmental temperature test chamber set for a temperature of +20 °C shall be used. If possible, connect an antenna to the output terminals of the EUT because use of a dummy load could affect the output frequency of the EUT. If the EUT is equipped with or uses an adjustable-length antenna, it should be fully extended.
2) Supply the EUT with nominal ac voltage or install a new or fully charged battery in the EUT. Turn on the EUT and couple its output to a frequency counter or other frequency-measuring device of sufficient accuracy, considering the frequency tolerance with which the EUT must comply.

   NOTE — An antenna connected to the measuring instrument with a suitable length of coaxial cable may be placed near the EUT (e.g., 15 cm away) for this purpose.
3) Tune the EUT to any one of the number of frequencies specified in 13.1.1. Adjust the location of the measurement antenna and the controls on the measuring instrument to obtain a suitable signal level (i.e., a level that will not overload the measuring instrument, but is strong enough to allow measurement of the operating or fundamental frequency of the EUT). Turn the EUT off and place it inside an environmental chamber, if appropriate, or position it as specified in 6.2. Allow sufficient time (approximately 30 min) for the chamber to stabilize at +20 °C before proceeding. Turn the EUT on and measure the EUT operating frequency at startup, and two, five, and ten minutes after startup. Four measurements in total are made.
4) If 13.1.1 requires measurements on only one operating frequency, proceed to step 5; otherwise, successively tune the EUT to each of the additional operating frequencies specified in 13.1.1. and repeat step 3.
5) If the EUT is powered from the ac powerlines, supply it with 85% nominal ac voltage and repeat steps 3 and 4 before proceeding to step 6. If the EUT is battery powered, proceed to step 7.
6) If the EUT is powered from the ac powerlines, supply it with 115% nominal ac voltage and repeat steps 3 and 4 before proceeding to step 7.
7) Prepare the final test report in accordance with Section 10.

I.6 Occupied Bandwidth Measurements

NOTE — Section 16 applies only to devices where these measurements are required by the procuring or regulatory agency.

1) Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external signal generator.
2) A spectrum analyzer or other instrument providing a spectral display is recommended for these measurements. Video filtering is not used during occupied bandwidth tests.

   NOTE — The bandwidth of the measuring instrument should be small when compared with the maximum allowed bandwidth in order to accurately measure the bandwidth of the transmitter with respect to the limit. Too small of a bandwidth would result in inappropriate measurements in certain cases; therefore, the measuring bandwidth shall be set to a value greater than 5% of the allowed bandwidth. If no bandwidth specifications are given, sue the following guidelines:

Fundamental Frequency Being Measured	Minimum Instrument Bandwidth
9 kHz to 30 MHz	1 kHz
30 MHz to 1000 MHz	10 kHz
1000 MHz to 40 GHz	100 kHz

3) Position the EUT as specified in 6.2. Supply the EUT with nominal ac voltage or install a new or fully charged battery in the EUT. Turn on the EUT and set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the specified bandwidth or -26 dB. Adjust the spectrum analyzer resolution bandwidth, sweep rate, and frequency scan with consideration to the frequencies used for modulation, so that the display is calibrated.
4) Apply modulation signal(s) as specified in 13.1.1.1 and measure the frequencies of the modulated signal from the EUT where it is the specified number of dB below the reference level set in step 3. This is the occupied bandwidth specified in 13.1.7. This may be done with plotted graphs or photographs of the measuring instrument display.
5) Prepare the final test report in accordance with Section 10.

I.7 Input Power Measurements

NOTE — Section I7 applies only to devices where these measurements are required by the procuring or regulatory agency.

1) Place the EUT as specified in 6.2. If possible, connect an antenna to the output terminals of the EUT because use of a dummy load could affect the output frequency of the EUT. If the EUT is equipped with or uses an adjustable-length antenna, it should be fully extended.
2) Supply the EUT with nominal ac voltage or install a new or fully charged battery in the EUT. Typical modulation shall be applied to the EUT during these tests.
3) Energize the EUT with rated supply voltage and set it to any one convenient frequency specified in 13.1.1. For measurement of the input power to the final RF stage, while varying the input modulation sources, measure the voltage at the supply to the final RF stage of the EUT, and the current into that stage, using a dc voltmeter and ammeter of appropriate ranges. The input power to the final RF stage is the product of these values. For input power measurements on an intentional radiator, use a voltmeter and ammeter and measure, as appropriate, either the ac or dc voltage and current at the ac power cord or battery input terminals of the intentional radiator. Again, the input power is the product of these values.
4) Prepare the final test report in accordance with Section 10.

Annex J Applicable Section of C63.4 by Equipment Type

(Informative)

J.1 Information Technology Equipment Applicable Sections

Test Facility Requirements:

Section 4	Measurement Instrumentation
Appendix F	Verification of LISN Characteristics
Section 5	General Requirements

Equipment Conditioning During Testing:

Section 6	General Operating Conditions and Equipment Configurations
Section 11	Measurement of Information Technology Equipment (ITE)*

Measurements:

Section 7	AC Powerline Conducted Emissions Testing
Section 8	Radiated Emissions Testing
Appendix D	Method of Preliminary Radiated Emissions Maximization
Section 11.5	AC Powerline Conducted Emissions Tests*
Section 11.6	Radiated Emissions Tests*
Appendix E	Step-by-Step Guidance for Testing Personal Computers and Associated Peripherals

J.2 Receiver Applicable Sections

Test Facility Requirements:

Section 4	Measurement Instrumentation
Appendix F	Verification of LISN Characteristics
Section 5	General Requirements

Equipment Conditioning During Testing:

Section 6	General Operating Conditions and Equipment Configurations
Section 12	Measurement of Unintentional Radiators Other than ITE*
Section 12.1	Measurement of Receivers*

Measurements:

Section 7	AC Powerline Conducted Emissions Testing
Section 8	Radiated Emissions Testing
Appendix D	Method of Preliminary Radiated Emissions Maximization
Section 12.1.3	AC Powerline Conducted Emissions Tests*
Section 12.1.4	Radiated Emissions Tests*
Appendix H1	AC Powerline Conducted Setup
Appendix H2	AC Powerline Conducted Emissions Testing
Appendix H3	Radiated Test Setup
Appendix H4	Radiated Emissions Testing

* Specific requirements.

Measurements That May Be Required:

Section 12.1.5	Antenna-Conducted Power Measurements*
Appendix H5	Antenna-Conducted Power Measurements for Receivers

J.3 TV Interface Device Applicable Sections

Test Facility Requirements:

Section 4	Measurement Instrumentation
Appendix F	Verification of LISN Characteristics
Section 5	Test Facilities

Equipment Conditioning During Testing:

Section 6	General Operating Conditions and Equipment Configurations
Section 12	Measurement of Unintentional Radiators Other than ITE*
Section 12.2	Measurement of TV Interface Devices*

Measurements:

Section 7	AC Powerline Conducted Emissions Testing
Section 8	Radiated Emissions Testing
Appendix D	Method of Preliminary Radiated Emissions Maximization
Section 12.2.3	AC Powerline Conducted Emissions Tests*
Section 12.2.4	Radiated Emissions Tests*
Appendix H1	AC Powerline Conducted Setup
Appendix H2	AC Powerline Conducted Emissions Testing
Appendix H3	Radiated Test Setup
Appendix H4	Radiated Emissions Testing

Measurements that may be required:

Section 12.2.5	Output and Spurious Conducted Level Measurements*
Section 12.2.6	Antenna Transfer Switch Measurements for Unintentional Radiators*
Appendix H6	TV Interface Device Output and Spurious Level Measurements
Appendix H7	Cable TV Antenna Transfer Switch Measurements
Appendix H8	TV Interface Device Antenna Transfer Switch Measurements

J.4 Low Power Transmitter Applicable Sections

Test Facility Requirements:

Section 4	Measurement Instrumentation
Appendix E	Step-by-Step Guidance for Testing Personal Computers and Associated Peripherals
Section 5	Test Facilities

Equipment Conditioning During Testing:

Section 6	General Operating Conditions and Equipment Configurations
Section 13	Measurement of Intentional Radiators*

* Specific requirements.

Measurements:

Section 7	AC Powerline Conducted Emissions Testing
Section 8	Radiated Emissions Testing
Appendix D	Method of Preliminary Radiated Emissions Maximization
Section 13.1.3	AC Powerline Conducted Emissions Tests*
Section 13.1.4	Radiated Emissions Tests*
Appendix 11	AC Powerline Conducted Setup
Appendix 12	AC Powerline Conducted Emissions Testing
Appendix 13	Radiated Test Setup
Appendix 14	Radiated Emissions Testing

Measurements that may be required:

Section 13.1.5	Operating Frequency Measurements*
Section 13.1.6	Frequency Stability Measurements*
Section 13.1.7	Occupied Bandwidth Measurements*
Section 13.1.8	Input Power Measurements*
Appendix 15	Frequency Measurements
Appendix 16	Occupied Bandwidth Measurements
Appendix I7	Input Power Measurements

* Specific requirements.